DISEASES OF CULTIVATED PLANTS AND TREES

GEORGE MASSEE

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BY

GEORGE MASSEE

ASSISTANT KEEPER, HERBARIUM, ROYAL BOTANIC GARDENS, KEW

AUTHOR OF 'A TEXT-BOOK OF PLANT DISEASES,' 'EUROPEAN FUNGUS FLORA,' 'BRITISH FUNGUS FLORA,' 'A MONOGRAPH OF THE MYXOGASTRES,' ETC. ETC.

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INTRODUCTION

So widely spread and, it may be added, often so intelligent is the interest now taken in the incidence and the dissemination of the diseases which affect cultivated plants, and at the same time so important is a proper conception of the causations and the treatment of these diseases, that a work which deals with them cannot fail to be welcomed. Much has been and much is daily being done to advance our knowledge of plant-diseases and to increase our ability to cope with the practical difficulties that their presence creates. But the literature of the subject is so widely scattered, and the results of individual investigations so often tend, when settling some immediate difficulty, to create new difficulties, to open up new lines of research, and to indicate new principles of treatment, that in the absence of a compact, general review of the actual state of affairs, the practical man is apt to feel at a loss as to how matters really stand, and at times is disposed to doubt the soundness of the advice he is urged to follow.

The conditions necessary for the preparation of such a work as is called for are in the first place an intimate knowledge of the labours of a host of investigators widely scattered throughout the world, with at the same time ready access to the literature in which these results are embodied. But, in addition to this, the work must be something very much more than a mere compilation of the statements of others; it must be the outcome of long-continued, personal investigation of the morphological and biological peculiarities of many types of the organisms that cause or are associated with cases of disease in plants, by a writer who is not only capable of

representing accurately the views of others, but is competent to give reasons for the faith which he himself professes.

Mr. Massee has already shown, and nowhere more notably than in *A Text-book of Plant Diseases*, published by him in 1899, second edition 1903, how fully he is endowed with the qualifications required in the author of a work like the present. Various passages in that Text-book, useful and trustworthy as it has proved as a guide to the results obtained up to the date of its publication, already, however, serve rather as records of what was then believed than of what is now actually known. A further issue of what has so soon become, in some respects, a historical landmark rather than a conspectus of existing information, being undesirable, Mr. Massee has found it preferable to prepare a new work on somewhat different lines and covering a rather wider field. This work, it is hoped, may take the place of the Text-book, the issue of which has become exhausted, and should prove as helpful to those who stand in so much need of assistance as its predecessor has done.

D. PRAIN.

ROYAL BOTANIC GARDENS,
KEW, 25*th January* 1910.

PREFACE

Diseases of plants are numerous and undoubtedly do much injury. This, however, is not so much due to a lack of known, reliable, preventive or curative methods, as to a lack of application on the part of those who should be most interested in the matter. If the various well proved remedial measures now known, which are neither exorbitantly expensive nor difficult of application, were honestly carried out, the loss from fungus and animal pests would be very materially reduced.

The most important of remediable and preventive measures combined is cleanliness. Unless this fact is constantly kept in view, and practised, no amount of spraying or other modern method of dealing with disease will produce the desired result. Just now spraying is the order of the day, and under certain conditions is productive of much good; at the same time spraying alone may be overdone, whereas when used in combination with other measures the success is greater and the cost less. Hundreds of people know, to their cost, that repeated sprayings do not always prevent Apple scab. Why? Because they do not remove the dead twigs on which the fungus winters. It is sometimes argued that this is impracticable, which is simply nonsense. The same is true of most of our diseases; the cultivator is led to believe by the manufacturer of spraying apparatus of various preparations warranted to cure everything, and frequently supported by expert opinion, that his salvation depends on spraying alone. Notwithstanding such persuasion and advice, the cultivator will find it to his advantage to remove the primary cause of disease whenever practicable, rather than allow it to remain, and

endeavour, by means of spraying alone, to keep it under subjection. Diseased branches, fruit, etc., should be removed—in fact, as far as practicable, all diseased material should be destroyed. Unfortunately it is not always possible to do so, as when potatoes attacked by Black scab, or turnips suffering from Finger-and-toe rot in the ground. In such cases the land should be sterilised by the use of quicklime or gas-lime.

Much has been written of late respecting the great advantage derived from certain fungi parasitic on insects. Such statements are perfectly true; myriads of destructive insects are destroyed by such means. This has happened in the past, and will continue in the future. The one thing to refrain from is that of investing money in any scheme having for its object the extermination of injurious insects through the agency of fungi. Any such investment will be regretted.

The numerous references given in this book indicate my great indebtedness to other investigators, to whom I respectively tender my best thanks. Finally, to my colleague, Mr. A. D. Cotton, I am indebted for calling attention to many subjects which would otherwise have been omitted.

GEO. MASSEE.

GATEACRE, KEW GARDENS,
January 28, 1910.

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DISEASES OF CULTIVATED PLANTS AND TREES

INTRODUCTION

SOME people are fully convinced in their own mind that diseases of cultivated plants increase in number and intensity year by year. In connection with this question it is important to remember that at the present day the majority of persons occupied in the cultivation of plants have learned to attribute every disease to some specific cause—generally a fungus or an insect; something that can be prevented, hence a disease. In bygone times the same amount of injury was considered as a 'visitation,' or due to 'blight,' or some equally indeterminable agency, and was accepted with calm resignation, and not counted as a disease. Cultivators have yet to learn that in addition to epidemics, primarily due to insects or fungi, of which there are admittedly many, numerous diseases of considerable importance are primarily due to physiological causes—bad cultivation; that system of horticultural gambling represented by an atmosphere saturated with moisture and an abnormally high temperature, which results too often in a general break-down of the constitution of plants subjected to such treatment. Such a constitutional weakening invites the attacks of fungi, which promptly complete, but do not originate, the calamity. Growers of tomatoes, cucumbers, etc., have not yet realised that there is a limit to the endurance of plants grown under highly abnormal conditions, and until they do so, they will be the greatest sufferers, as preventive measures under such conditions are, I believe, impossible. It is a pure speculation, yet judging from a somewhat extensive experience, is sufficiently often a success to justify its continuance.

As to whether plant diseases are more prevalent at the

present day than heretofore is an open question, and can only be answered by a comparison of the area under cultivation with the annual loss due to disease at the present day, as compared with that of some twenty-five years ago,—which is an impossibility.

There are many causes which favour the spread and increase of disease at the present day, which had no existence in bygone times; perhaps the most potent is that commonly known as 'rapid transit.'

Undoubtedly a change of seed is good, but, as experience has proved, you never know what disease you are introducing, and in many instances it is impossible to detect anything wrong until too late. The facility with which seeds, tubers, and even living plants can now be sent to the uttermost parts of the earth is a source of great danger from the point of view of introducing new diseases, and unless something in the way of a quarantine is insisted upon in every country, it appears highly probable that in course of time those diseases, which assume the proportions of an epidemic, will be equally abundant wherever the host-plant is cultivated. Where total prohibition is not considered necessary, quarantine, which has answered so well in the case of animal diseases, might with advantage be applied in the case of fruit-trees, etc. The trees should be planted in some suitable place, and be examined from time to time by some qualified person. After a season's growth they might be allowed to pass into the country, if free from disease.

I am quite aware that some people will say this idea is not practicable, and further, such precautions are not necessary. There is certainly nothing impracticable; it is quite as easy to plant a tree in one place as another. The cost of a tree that has been in quarantine for a season would certainly cost more than it would at the moment of landing, but on the one hand the purchaser would secure a tree free from disease, whereas on the other hand the tree might prove to be infected with some disease. The fact that the most destructive diseases attacking fruit-trees and other plants in Europe, also eventually appear in whatever part of the world such trees are cultivated, is absolute proof that the disease has been conveyed along with the plant.

PRIMARY AND SECONDARY CAUSES OF DISEASE

It is often a most difficult matter to ascertain with certainty the primary cause of a given disease. In most instances a secondary agent is credited with this power, simply because the part the secondary organism plays in the development and extension of a disease is more obvious and more easily followed and demonstrated than the true primary cause, which alone enabled the secondary one to gain a foothold. What I mean is illustrated as follows. The common disease known to gardeners as 'damping off' in seedlings, is generally considered as being primarily due to a minute parasitic fungus called *Pythium debaryanum* (Hesse). At the same time it is perfectly well known that it is only under certain conditions of cultivation that the fungus can attack seedling plants, and those conditions in themselves are the worst under which seedlings can be cultivated, namely, excess of moisture and shade. When seed-beds are located in open, well-drained, and well-lighted situations 'damping off' is unknown, simply because such conditions are inimical to the growth of the parasite. In this instance, personally I attribute 'damping-off' to a bad method of cultivation. The explanation is briefly as follows. *Pythium* is one of those types of fungus but little removed from primitive aquatic forms, its reproductive bodies consisting of motile zoospores which can only reach their destination through the agency of water. The necessary film of moisture is ever present on the stems of seedlings grown in damp, shaded, and badly ventilated situations. Again, the cell-walls of plants grown in damp places are very thin, and the cells are always turgid with watery cell-sap, thus presenting the conditions absolutely necessary for enabling the zoospores of *Pythium* to penetrate the cell-walls, and gain an entrance into the tissues of the plant. When zoospores are placed on the stem of a seedling plant grown in an open situation, well exposed to light and air, no infection takes place.

The host of fungi known as wound-parasites, usually considered as originators of disease, are, in reality, only secondary agents, although in the majority of instances the greatest amount of injury resulting is due to their presence. Among such may be enumerated most of the fungus diseases of forest and fruit trees. As indicated by the name wound-

parasites, the spores of these fungi cannot effect an entrance through an unbroken surface, but only through some wound. Many kinds of wounds to which trees are liable, as those caused by hailstones, frost, branches broken by wind, etc., are beyond our control; on the other hand, the injuries caused by bad pruning, by workmen in planting trees, neglecting to protect cut surfaces at once by a coating of gas-tar, and many other examples, may be cited as primary causes of disease, over which we have the means of perfect control, which are but rarely applied.

An epidemic, say, caused by a fungus, is usually the outcome of the spores of that particular fungus having been previously present in the vicinity, hence, honestly speaking, I consider sheer negligence as the most frequent primary cause of disease, as when diseased plants are left lying about instead of being promptly burned or buried. More will be said on this subject under the heading, Cleanliness.

On the other hand, numerous insects, mites, eelworms, fungi, and even flowering plants are undoubtedly primary causes of disease. There is no denying the fact that many different kinds of insects, during some period of their development, attack and destroy perfectly healthy plants. The same is true of the minute organism called *Plasmodiophora*, which is the primary cause of the disease known as 'anbury' or 'finger-and-toe,' in the roots of turnips, cabbages, and various other cruciferous plants. Aphides or 'green-fly' of various kinds, *Thrips*, 'eel-worms,' and 'scale-insects,' of which the 'woolly aphis' or American blight is a well-known example, also belong to the same category.

Among fungi, as primary causes of disease, may be enumerated the whole of the great family popularly known as rusts—wheat rust, hollyhock rust, etc.; the 'smuts' and 'bunts' of cereals. Finally, flowering plants furnish such destructive parasites as the 'dodders,' which attack flax, clover, hemp, etc. The broom-rapes and mistletoe also kill or injure other plants.

In some instances the presence of one parasite renders the host more susceptible to the attack of a second parasite. I have proved by means of repeated experiments that the very destructive disease known as larch canker, caused by the fungus *Dasyscypha calycina* (Fckl.), is enabled to establish itself at new points on the tree, where the surface has been wounded by the larch aphis (*Chermes laricis*). In like manner apple

canker, caused by *Nectria ditissima* (Tul.), finds a suitable starting-point on the branch of an apple-tree that has been wounded by the woolly aphis (*Schizoneura lanigera*). Not only does the aphis make wounds in which the canker fungus can commence growth, but it also unconsciously conveys the spores of the fungus to new sites as it moves about. Perhaps it is not stating too much to say that if the larch aphis and the woolly aphis could be exterminated, larch canker and apple-tree canker would cease to exist, at all events under the form of destructive epidemics.

Norton, an American observer, considers that the brown rot of fruit (*Sclerotinia fructigena*, Schröt.) follows insect bites or other injury.

Massee, G., 'Larch and Spruce Canker,' *Journ. Bd. Agric.*, 9, p. 176, 3 pl. (1902).

Massee, G., 'Canker fungus and Woolly Aphis,' *Journ. Bd. Agric.*, 13, p. 55 (1906).

Norton, J. B. S., 'Plant Diseases in Maryland in 1902.'

EPIDEMICS

It is a well-known fact that epidemics or sudden outbursts of disease, extending over a considerable area, are fortunately sporadic in their occurrence. The presence of an epidemic does not prove that an exceptionally large number of fungus spores were present, and that these accounted for its occurrence. This would imply an excess of fungus growth the previous season, which is not in accordance with experience. The various diseases which every now and again assume the proportions of an epidemic, are usually caused by fungi quite general in the district and always present, and probably the necessary number of spores required to start an epidemic are also always present. This being the case, it follows that the presence, in sufficient quantity, of both the proper host-plant and of the fungus are alone not sufficient in themselves to set up an epidemic; another factor is necessary, namely, suitable atmospheric conditions.

A few illustrations will make clear the above statement. Marshall Ward appears to have had some similar idea in mind when he wrote the following: 'Suppose we take a potato plant, the leaves of which are very slightly marked with disease

spots, and divide it into two halves as exactly as possible, and place each half in a tumbler of water; the two tumblers with their half-plants are then placed in an ordinary room, side by side, at a temperature of about 20° C., and one is covered close with a bell-jar, and the other left uncovered. In a short time—often a few hours—the covered leaves become black and rotten with the disease; whereas the uncovered one will go on looking fresh for several days, though it also succumbs at once if covered. The question arises whether the rapid spread of the fungus and the rot it causes here are simply owing to the increased supply of water, as the tissues become turgid in the saturated atmosphere under the bell-jar; or whether we have not here again, in addition, a case where the diminished access of oxygen to the interior of the tissues of the host results in the accumulation of organic acids and other substances, which make the excessively turgid cells and thin watery cell-walls more than usually easy prey to the parasite.'

This experiment, I consider, supports my contention that disease caused by fungi is dependent on weather conditions; or to state the case more exactly, it depends on an excess of moisture in the air and absence of sunshine; a 'muggy' or 'stuffy' condition, as it is termed in the country. As to whether the disease is accelerated by moisture or by lack of oxygen, although very important in itself, has no bearing on the contention that atmospheric conditions alone can cause an epidemic of potato disease, for even if it is proved that lack of oxygen is the determining factor, such lack of oxygen in the tissues of the potato is due to the presence of an excess of moisture in the air. No one ever saw or even heard of an epidemic of potato disease during a dry season.

The following experiments, conducted at Kew, show still more clearly the effect of weather conditions in accelerating or retarding fungus diseases. Three potatoes showing rusty stains in the flesh, indicating the presence of the mycelium of potato disease (*Phytophthora infestans*), were each cut into two equal parts. Each half potato was planted separately in a plant pot, the soil and manure used being the same for all, and was sterilised by steam. Three of the pots were placed in a house having a temperature ranging between 70° and 80° F., and very often with moisture at saturation point. Each pot was covered with a bell-jar. The remaining three pots were placed in a house without any artificial heat, and having

the air exceptionally dry. These pots were not placed under bell-jars. An equal amount of water was supplied to each of the six pots. The stems and leaves of the three plants grown under conditions of high temperature and much moisture were attenuated and weak. The *Phytophthora* first appeared on these plants six weeks after planting, and a fortnight later all three plants were blackened and destroyed by the fungus. The potatoes grown in the cool, dry house were perfectly healthy when two months old. At this time one of the plants from the cool house was removed to the hot, damp house, and placed under a bell-jar. Within nine days this plant was completely blackened and killed by the fungus. A fortnight later a second potato plant, showing no indication of disease, was removed from the cool to the hot house, and placed under a bell-jar; within a week this plant was also killed by the *Phytophthora*. The third plant was allowed to remain in the cool house, and at the end of thirteen weeks, when the experiment ended, showed no trace of disease. Similar results were obtained by using potato tubers containing mycelium of the fungus causing potato 'leaf-curl' (*Macrosporium solani*).

These experiments I consider to prove that the outbreak of an epidemic of potato disease—also other epidemics—is due entirely to weather conditions.

Secondly, they prove that even when the disease is actually present, that is, when the mycelium of the fungus exists in a living condition in the tuber of the potato, its development to the extent of manifesting itself in a fruiting condition, or doing any material injury to the plant, depends on atmospheric conditions. This again points to the conclusion that when a crop of potatoes has grown vigorously and remained apparently healthy up to a certain point, and then suddenly collapses under the influence of the *Phytophthora*, the epidemic is not necessarily due to the infection of the plants by spores conveyed by wind or other agents, but rather that the disease was already present in the plants, and only awaited favourable climatic conditions for manifesting itself in a dominant form.

Thirdly, these experiments prove that the occurrence of potato disease does not in all instances depend on the infection of plants by floating spores. The mycelium present in the tuber can give origin to the disease. This being so, it follows that the disease can be conveyed from one country to another in a manner that defies detection.

The development of an epidemic of fungus disease upon weather conditions may not be universal, but it undoubtedly applies to other than potato disease. Who ever saw or heard of an epidemic of cereal rust during a hot, dry season, or an outbreak of peach 'leaf-curl,' excepting following a sudden snap of cold, dull, damp weather, preceded by conditions favourable to the growth of the peach-tree.

Traditional beliefs die hard: the ideas of farmers and gardeners concerning the cause of mildew, blight, etc., are very much the same to-day as they were centuries ago. It is the common practice of scientists to smile, or even to sneer, at such antiquated notions, nevertheless there is generally a substratum of truth in these old traditions, the outcome of centuries of observation; in fact the arguments advanced by such people are often quite correct as far as they go, and only fail where they could not possibly be expected to succeed, that is in giving a scientific interpretation of the facts observed.

Atmospheric conditions have undoubtedly much to do with determining whether a given plant can be infected or not; or even, when infection has taken place, whether the parasite can manifest itself to any injurious extent. The practical man believes that blight, mildew, etc., are caused by cold east winds in the spring. This is quite correct as far as it goes, and all that the scientific man knows in addition is the fact that mildew and blight are due to a fungus, the growth and development of which is favoured by the weather conditions indicated above. It is common knowledge that when favourable conditions for plant growth are continuous, fungus diseases are absent or very much in abeyance: whereas a genial period in the spring, followed by a cold spell of east wind or frost is as certainly followed by blight, or a rapid development of fungus growth.

The man who grows potatoes knows too well that a period of cloudy, damp, warm weather will be followed by potato disease. The fungus was already present in the potatoes, but so long as conditions favoured the growth of the potato plant, the fungus could not make headway. The atmospheric conditions indicated prove unfavourable for the continuous healthy growth of the potato plant, but, on the other hand. favour the growth of the fungus, and an epidemic is the result, more or less severe, depending entirely on atmospheric conditions.

The connection between barberry bushes and wheat rust has been upheld by farmers for centuries; in fact an act of legislation for the destruction of barberry bushes was passed more than one hundred and fifty years ago. This idea was generally ridiculed by scientific men until De Bary commenced an investigation of the subject, and, as all the world knows, the result proved the farmers' contention to be correct. The matter, however, did not end here. De Bary in investigating the subject discovered the condition known as heteroecism, or the fact that certain fungi live during different periods of their life-cycle on different host-plants, and assume an appearance very different under the two conditions. This discovery, one of the most brilliant amongst botanical discoveries of any age, has proved equally important from a purely scientific and an economic standpoint, and yet its discovery was suggested by what was generally considered as a myth.

When I was a boy I remember often hearing my father, who was a farmer, discuss with friends the nature and origin of 'finger-and-toe' or 'anbury,' which about that time was rapidly spreading, and doing serious damage to the turnip crop. Opinion as to the nature of the disease was various, but all agreed that its appearance was due to the substitution of artificial manure, crushed bones, etc., for farm-yard manure and lime. This opinion proved to be perfectly correct. Thirty years later I proved, by a series of experiments conducted at Kew, that the organism causing 'finger-and-toe' in turnips, cabbages, etc., and other plants belonging to the crucifer family, required an acid medium for its development, and that an alkaline medium arrested its growth. The 'finger-and-toe' disease was probably always with us, but its rapid extension was rendered possible only by the considerable amount of acid present in many artificial manures. Lime is the best known check to the disease.

The question that naturally suggests itself is, why do the weather conditions indicated above favour the development of parasitic fungi? No complete answer is forthcoming, but, speaking broadly, such conditions indirectly provide the fungus with a greater supply of food. Parasitic fungi are always present in greater or less quantity, even when disease is generally considered to be absent. During a continuance of warm bright weather, plants produce a large amount of starch during daylight. During the night (and to some extent also during the day) this solid starch is converted into

soluble glucose, which is conveyed to those parts of the plant where growth is proceeding. This soluble glucose or its modifications, sugar, etc., along with other cell-contents, constitute the food of parasitic fungi; during fine weather when a plant is actively growing, the daily supply of glucose and other substances is monopolised by the plant itself, and the fungus present is literally starved, or obtains so small a share of food that it is but little in evidence. On the other hand, during a spell of weather unfavourable to the plant, growth is more or less suspended, the amount of starch after conversion into glucose is not quickly attracted to growing points, but in common with other substances formed under conditions unfavourable for growth more or less saturates the tissues, and consequently supplies the fungus with a copious supply of food. Infection of a plant by fungus spores is also most readily effected under the conditions indicated, hence an epidemic follows. It is common knowledge that only the young and actively growing parts of plants are attacked by the majority of kinds of parasitic fungi. This is because at such points there is the greatest concentration of soluble glucose and other constructive substances required by the fungus. For this reason the mycelium of *Phytophthora* present in the tuber of a potato follows the growing stems; it also explains why the 'bunt' fungus, that attacks seedling oats in the ground, follows the upward growth of the plant, being always most in evidence at the tip or growing-point, where its food is in greatest abundance.

The above remarks apply more especially to the first or conidial form of parasitic fungi, which is most markedly parasitic in habit; the later stages of the same fungus usually develop on the fading or even dead host-plant, and are consequently more saprophytic than parasitic in their nature.

HOW PLANTS ARE INFECTED BY FUNGUS SPORES

It is a well-known fact that the spores of a given parasitic fungus cannot infect indiscriminately every kind of plant that the spores happen to alight upon. On the other hand, the majority of the most destructive parasites known can only infect and set up a disease on one particular kind of plant, or at most, a few closely related plants.

The fungus causing potato disease, since its introduction to

Europe, has spread from the potato to weeds belonging to the potato family only. In like manner the hollyhock fungus (*Puccinia malvacearum*), which followed the hollyhock to Europe, has only succeeded in infecting European weeds belonging to the hollyhock family. The rust of wheat (*Puccinia graminis*) has followed wheat throughout the world, but has not been able to extend its range of host-plants beyond that of a few grasses belonging to the wheat family. Now it is perfectly certain that the spores of all these fungi, which are produced in myriads, must necessarily have alighted times out of number on living leaves of hundreds of different kinds of plants, so that it cannot be for lack of opportunity that a more varied assortment of plants have not been infected.

In the instance of some highly specialised fungus parasites, it has been shown that the power of infection is much more restricted than in the examples given above. In some cases only one kind of plant can be infected, or even only one particular form or variety of a plant.

If these well-proved facts are borne in mind, much loss of time and expense might often be saved. In one instance a plum-tree, growing near to a house in which cucumbers were grown, was cut down because its leaves were infested with plum 'leaf-rust' (*Puccinia pruni*), as it was assumed that the 'leaf-rust' was also the cause of cucumber 'leaf-blotch,' due in reality to a totally different fungus (*Cercospora melonis*), which is quite as incapable of infesting plum leaves as the *Puccinia* is of infesting cucumber leaves.

The reason for the apparent selective power exercised by fungi in infecting plants, I have dealt with in detail elsewhere. The following are the most essential points bearing on the subject. When the spores of a fungus are made to germinate in water, the presence of certain substances can be shown to exert an attractive influence on the germ-tubes of the fungus; in other words, the germ-tubes formed by the spores grow towards the substance in question. Other substances are found to exercise an opposite effect on the germ-tubes, which are repelled, or grow in a direction away from the exciting substance. This directive action of certain substances in solution, on the germ-tubes of fungus-spores is called chemotropism; positive when the germ-tubes are attracted; negative when they are repelled.

Every degree of parasitism exists amongst fungi, ranging from those very highly differentiated forms that are restricted

in their parasitism to a single kind of plant, or even to a particular variety of a plant, through those fungi that are restricted to a group of closely allied plants; ending with those whose parasitism is yet in a rudimentary or incipient stage, and consequently exhibit but little discrimination in the selection of a host, but attack many different kinds of plants when conditions are favourable. The last-named category of parasites can also live as saprophytes when favourable conditions for parasitism are not forthcoming.

Now chemotropism is the force that enables a parasitic fungus to gain an entrance into its host-plant. In the most highly differentiated parasites the germ-tubes of the germinating spores have become so sharply specialised that they respond to, or are only attracted by, some special chemotactic substance or substances met with only in the cells of the one particular kind of plant they have adapted themselves to. Of course the spores of the most highly specialised parasites germinate on the surface of any or every kind of plant on which they happen to alight, but if the chemotactic substance attractive to the fungus is not present, the germ-tube of the fungus is not attracted into the tissues of the plant, and infection does not follow. To this category belong several kinds of 'rust' fungi attacking cereals and other grasses.

A second batch of parasites, including those causing the hollyhock and the potato-diseases respectively, are somewhat less specialised than the members of the preceding group, and respond to the chemotactic substance characteristic of a certain family of plants.

Even in the very worst cases of an epidemic it is not unusual to find that certain plants of the kind attacked remain perfectly free from disease. On investigating such individuals I discovered that their freedom from disease was due to the absence of the special chemotactic substance that enabled the fungus to infect the plant; in other words, such plants were immune to that particular disease.

This discovery should prove to be of value in any attempt to produce strains of plants immune to their most destructive parasite. Until quite recently attempts in this direction have been based on the production of a more resistent cuticle, formation of bloom, or some other structural character that would prevent the entrance of the germ-tubes of the fungus into the tissues of the host-plant. Marshall Ward has paid special attention to this subject, and

has come to the conclusion that the respective susceptibility or immunity of species of *Bromus* against the attack of species of *Puccinia dispersa* is not at all influenced by structural characters. His conclusions are summarised as follows: 'The capacity for infection, or for resistance to infection, is independent of the anatomical structure of the leaf, and must depend on some other internal factor or factors in the plant.' The factor for insuring infection I consider to be the presence of a chemotactic substance in the plant, to which the germ-tubes of the parasite respond. The factor for immunity, if it may be so stated, is the absence of the necessary chemotactic body.

Infection of plants by the spores of parasitic fungi occurs chiefly during the night in a state of nature. The following account of an experiment bearing on this point, which I have previously recorded, may be repeated here. 'A batch of vegetable marrow plants in my garden were badly attacked by [a mildew] *Sphaerotheca humuli*. Twelve young leaves, showing no trace of the disease, were selected for experiment. Six leaves were protected during the day (6 A.M. to 6 P.M.) in paper bags, and left exposed during the night. Six other leaves were enclosed in bags during the night (6 P.M. to 6 A.M.) and exposed during the day. This arrangement was continued for a week; those leaves that had been exposed during the night only were white with the mildew at the termination of the experiment, whereas those leaves that had been exposed during the day only were free from the disease with the exception of a few very small patches on three of the leaves.'

Some of the reasons why infection occurs during the night chiefly, are as follows. The surface of leaves is covered with a film of moisture, a condition necessary to enable the spores to germinate on the surface of the leaf, previous to the germ-tubes entering the tissues. Owing to retarded transpiration or loss of water, by the leaves, the cells become more fully distended with liquid contents, a condition favourable for infection. The starch formed during the day becomes dissolved during darkness into soluble glucose, and this along with other substances furnishes an excess of food which practically saturated the leaves, and possibly the necessary chemotactic substances are present in greater abundance also.

During a succession of very dull, damp days, conditions

are also favourable for infection. It will be noticed that the symptoms described above agree in the main with the gardener's conception of 'soft' foliage, a condition which is well known to favour the development of disease. Now plants grown under glass, more especially when exposed to an abnormally high temperature and excess of moisture, have comparatively speaking always 'soft' foliage, and consequently are more susceptible to fungus disease than plants of the same kind grown under more natural conditions.

HOW FUNGUS DISEASES ARE DISSEMINATED

It is very important to remember that fungus diseases may be disseminated in different ways. (1) By means of spores or specially produced reproductive bodies. (2) By what is termed a vegetative method, that is by a portion of the mycelium of the fungus present in the seed or some other portion of a plant, as rootstock, tuber, bulb, etc. The mycelium remains in a passive condition until the seed or tuber commences growth, when the mycelium grows up along with the new plant. This method of infection is most dangerous and most difficult to prevent, as the seed, or whatever portion of the plant harbours the mycelium, is infected every year, the fungus simply passing from the old to the new generation without ever leaving the plant. (3) Sclerotia or concentrated masses of mycelium, replete with food, are also often formed in the substance of bulbs, tubers, etc.

In dealing with infection by means of spores, it is again necessary to treat the subject from two standpoints, (1) The spread of disease from one locality or district to another in the same country.

Wind is undoubtedly an important factor in distributing spores within a limited area, as are also insects and various kinds of mites and other minute creatures that creep or fly about from one plant to another. Birds, rabbits, and hares also carry spores from one place to another. Snails and slugs are responsible to a considerable extent for the diffusion of spores, and consequent spread of disease. Many kinds of fungi are eaten by slugs, and so far as is at present known the spores of some kinds of fungi germinate only after having passed through the alimentary tract of a slug. Slugs are eaten by toads, and here again we have an additional agent in effecting the dispersion of spores. If a slug is placed on

the leaf of a plant covered with mildew and allowed to crawl about for some little time, and is then placed on another leaf of the same kind free from disease, and again allowed to crawl about, within two or three days the track made by the slug on the previously healthy leaf will be covered with mildew. The slimy surface of the slug picked up spores from the infected leaf, and in moving about, deposited them on the healthy leaf. This is what slugs do constantly of their own accord. As specific instances of the unconscious transportation of fungus spores by insects, the following may be noted:—The well-known 'stinkhorn' (*Phallus impudicus*), in common with all the members of the family to which it belongs, has become specially adapted for the purpose of utilising flies as agents in dispersing its spores. When mature the fungus emits a very strong and, from the human standpoint, exceedingly offensive smell. The very minute spores are imbedded in a green semi-liquid mucus which has a very sweet taste, and is produced in such quantity that it drips from the fungus if not removed. Attracted by the strong smell, numerous flies assemble and feed greedily on the spore-laden sweet mucus. By this arrangement the spores are not only removed in immense quantities on the feet and proboscides of the flies, but a copious growth of mycelium has been obtained from the dung of flies that had been fed on the mucus.

The dangerous fungus parasite called 'ergot' (*Claviceps purpurea*), which grows from the grain of rye, wheat, and many other grasses, has two forms of spores. The summer spores produced on black, horn-shaped bodies, springing from the grain, are exceedingly minute, and are imbedded in a quantity of sweet mucus. This sweet substance forms the food of certain kinds of flies, who, in visiting healthy grass-flowers, leave some of the spores adhering to their proboscides on the stigmas, thus securing infection.

The fungus causing 'apple canker' (*Nectria ditissima*) is a wound-fungus, that is, its spores cannot effect an entry into the unbroken surface of a plant, but only through wounds caused by some other agent. The *Nectria* is an indigenous fungus, and has always been with us, and in all probability always will be, but during late years it has become much more aggressive, and epidemics of 'canker' are too frequent at present. This rapid spread of 'canker' coincides with the introduction and spread of the 'American blight' or 'woolly

aphis' (*Schizoneura lanigera*) into this country. The wounds and gouty swellings made on the branches by the 'woolly aphis' are exactly of the nature required by the 'canker' fungus to enable it to effect an entrance into the living tissues of a branch. When the fungus has once established itself and produced fruit, the 'woolly aphis,' aphides, and other insects, again lend their aid, by carrying the spores from one part of the tree to another. The result is an epidemic of 'canker.' As the result of extended observation on this matter, I think it would be scarcely an exaggeration to say that if we had no 'woolly blight' we should have no 'canker,' that is in the sense of an epidemic.

A whole volume could be written on the subject of spore dispersion, but perhaps sufficient has been explained to indicate the various possibilities by which this object can be attained. The subject cannot, however, be dismissed without some allusion to the part played by man in this connection. When a crop of any kind has been attacked, portions of the diseased plants are constantly left on the ground, even when it is practicable to remove such; in many instances owing to rapid decay such a course is not possible. In such cases the diseased plants eventually decay and liberate the spores in the soil, where they remain for some time in a living condition, ready to infect any subsequent crop. The matter, however, does not end here; the infected soil may be, and is, constantly conveyed from one field to another by adhering to the wheels of carts, implements, and in various other ways that will suggest themselves. When an epidemic breaks out in plants grown under glass, as in a cucumber house, in some instances many precautions are taken to prevent the disease from spreading to other houses, but it rarely, if ever, occurs to those concerned that spores may be carried on the clothes or hands of workmen, although such is the fact. Of course it may be urged, and with good reason, that it is practically impossible to guard against such cases, nevertheless it is well to be acquainted with the possibilities.

Too frequently when an endeavour is made to remove and destroy diseased material, the attempt is not a success, owing to lack of knowledge as to the amount of apparently drastic treatment spores can undergo, without material injury. Mildewed peas, rusted bean straw, diseased fruit, mangolds, etc., are carefully collected and thrown into the piggery or some similar place, on the supposition that they will either be eaten

or trampled into manure. In either case myriads of spores escape destruction, and are eventually returned to the land in a condition favourable for infecting any suitable crop. The same remarks apply to rusted straw.

Passing to the spread of disease from one country or even from one continent to another, we have mostly to deal with economic plants that have been introduced to distant countries from Europe. It is too frequently the case that either from the first, or after an interval of time, such introduced plants are attacked by the same kind of fungus disease from which they suffer at home.

Three different reasons have been advanced in explanation of these outbreaks of disease in a distant country, caused by fungi that are natives of Europe. The first, which is now almost universally discredited, assumed that the spores of fungi were carried immense distances by wind, as from Europe to Australia for example. The second reason is based on the assumption that those particular kinds of fungi that attack plants of economic importance are widely distributed, are in fact practically everywhere, lying in wait as it were for the advent of introduced plants. There are many grave reasons against this view. Fungi conform to the laws of geographical distribution as other plants do, and if we admit this reasoning, we must also admit that it applies mainly to those fungi that happen to cause damage to economic plants. No other kinds of fungi are known to be cosmopolitan.

The fact that wheat rust occurs now on some indigenous Australian grasses, or that broad bean rust is now met with on indigenous New Zealand weeds, does not prove that these fungi are indigenous to Australia or New Zealand respectively, or that they existed there before the advent of wheat and broad beans, as is advocated by some authorities.

Every one is agreed that the hollyhock rust (*Puccinia malvacearum*) is an alien in Europe, and that by some means it followed its host-plant to that continent. At the present day this rust has attacked practically every kind of European wild plant belonging to the hollyhock family. Now suppose this indisputable fact not to have been known, it might, and probably would, have been argued that the hollyhock was attacked on its arrival in Europe by a fungus common on European mallows. The same remarks apply to the fungus causing the destructive potato disease. The fungus by some means followed its host-plant, and has since

spread to most European wild plants belonging to the potato family, and also to some cultivated representatives of the family, as tomatoes, etc.

The history of the introduction and spread of alien fungi has yet to be written, but the examples given, with others that could be enumerated, afford absolute proof that such a condition of things does in reality exist, and probably to a considerable extent.

My own opinion is that when a plant is attacked by the same fungus in a distant country, as that from which it suffers at home, the fungus was in some way conveyed with the seed of the plant. This refers to those plants that can be introduced by means of seed, as cereals; leguminous plants, as beans, peas, lucerne, clover, etc.; mangold, beet, and many other plants. In the case of 'bunt' (*Ustilago*) attacking cereals, we have absolute proof that spores are carried along with the 'seed'; why should a similar method of conveyance be denied in other instances?

At Nairobi, in British East Africa, climatic conditions are favourable for the cultivation of many economic plants grown in this country. Wheat, broad beans, and French beans were sown, and for a time promised well, but eventually one and all were completely destroyed by a fungus epidemic. On examination it was found that each kind of plant had succumbed to the same species of fungus known to be destructive to these plants at home. The wheat was destroyed by rust (*Puccinia graminis*); a small amount of 'bunt' (*Tilletia caries*) was also present. The broad beans were covered with rust (*Puccinia fabae*), and the pods of the French beans were distorted by the fungus called *Colletotrichum lindemuthianum*. Now, is it more reasonable to assume, in the absence of positive proof, that these kinds of fungi were already growing on indigenous plants at Nairobi, than to assume that spores were carried from England along with the seed? I think not. All varieties of beet and mangold originated from the wild beet. Now wild beet is attacked by a rust called *Uromyces betae*, and this fungus passed on to the cultivated varieties, and has followed them to South Africa, Australia, New Zealand, United States, etc. The wild beet is absent from each of these countries, and beet rust only occurs on beet, hence if the fungus was not conveyed with the seed, how did beet become infected in New Zealand and other distant countries?

Numerous other instances could be given of economic plants that have been introduced to distant countries falling victims to the same fungus disease from which they suffer at home; in fact this is true of every plant widely cultivated, and I think proves my contention that the germs of the disease are conveyed along with the seed in those instances where seed is the only means by which a plant can be introduced into a new country.

In those cases where living plants, as fruit-trees, are sent to distant parts, there is the double risk of introducing disease. The fungus may be actually growing on the plant, or spores may be nestling in tiny crevices or cracks in the bark or adhering to the roots. Most destructive diseases, however, attack the foliage and fruit, as 'apple scab' (*Fusicladium dendriticum*); 'brown rot' (*Monilia fructigena*); 'bitter rot' (*Gloeosporium fructigenum*); 'shot-hole' fungus (*Cercospora circumscissa*), etc.; but as trees are exported during the resting condition, when leaves and fruit are absent, these diseases could only be conveyed under the form of spores. It is quite possible, however, that the spores of many parasites may be introduced along with ripe fruit in a living condition, and, opportunity offering, establish a disease in a new district. Other parasites, as apple-tree 'canker' (*Nectria ditissima*), grow on the trunk or branches, and could thus readily be carried from place to place.

The importation of rusted straw into a country is always a source of danger to cereal crops. It has been proved that even uredospores or summer spores retain their vitality much longer than was at one time imagined. It only requires that such rusted straw should be placed in the vicinity of a growing crop, and the possibility or even probability of infection is great.

Certain kinds of minute fungi, *Ascobolus*, *Pilobolus*, etc., that only grow on the dung of herbivorous animals, have followed colonists to every part of the world.

These fungi eject their spores to a considerable distance, some of which alight on living grass growing in the vicinity of the dung on which the fungus is growing. When the spores alight on grass, they are fixed by a kind of mucilage which hardens when exposed to the air, and is not soluble in water. If grass bearing these spores is eaten by some animal, the spores commence germinating in the alimentary canal, and soon produce a new crop of fungi on the dung. When hay

bearing such spores is shipped as fodder, or used for any other purpose, and on its arrival in another country is eaten by some animal, the probable result is a crop of fungi on the dung.

Respecting diseases that can be dispersed by vegetative methods of fungus reproduction, mycelium hibernating in seeds, bulbs, tubers, etc., I have already shown that in the case of the potato, the potato blight, also potato 'leaf-curl' can be introduced from one district or from one country to another without the possibility of detection. Unfortunately, two other potato diseases come under the same category. 'Black scab' is one of these. In its most pronounced form this disease is very conspicuous and unmistakable, but as I have proved by many experiments, the spores may be present in the 'eyes' of a potato tuber without betraying their presence until the potato begins to grow, when the young shoots are at once attacked. The fourth disease, known as 'black leg' is caused by a bacterium (*Bacillus phytophthorus*), and hence is outside the realm of fungi.

Some members of the family forming 'smut' have mycelium perennial in the host-plant. In *Scilla bifolia* the 'smut' in the anthers originates from mycelium present in the bulb. This mycelium persists in the bulb from year to year, hence the anthers are always 'smutted.' Furthermore the perennial mycelium present in those bulbs which produce young bulbs passes into the latter, consequently every bulb originating from a diseased parent inherits the disease, in fact it is what we call in other instances 'constitutional.' Smut in the anthers of *Lychnis diurna* also originates from hibernating mycelium present in the root.

Carrots are often much injured by a minute fungus called *Phoma sanguinolenta*; when the disease is slight and escapes attention, the roots may be planted the following year for seed. If this occurs, the mycelium of the fungus hibernating in the root passes up into the stem and prevents the formation of seed. The hibernating mycelium of *Peronospora schachtii* in the crown of beet and mangolds acts in a similar manner.

The very destructive disease known as peach 'leaf-curl' has perennial mycelium in the branches, which grows along with the shoot and enters the leaves each year. When the leaves have fallen it is often impossible to detect the presence of the fungus, and such infected trees could be sent to any part of the world, and thus distribute the disease.

In cases of true parasitism the relation between parasite

and plant attacked is very one-sided; the parasite is provided with a home, and feeds entirely on those substances which its host-plant had prepared for its own use. Thus the parasite obtains all that it requires at the expense of the host-plant, while the latter derives no benefit whatever, but otherwise, from its parasite. In some instances, however, the relation between what were in the first instance parasite and host respectively, has become so much modified that the two live together and derive mutual benefit from each other's presence. This condition of things has reached its climax in the Lichens. Each lichen is a combination of a fungus and one or more kinds of alga, which are morphologically quite independent of each other, yet fungus and alga respectively do a certain amount of work in connection with the production of food that the other constituent could not perform. This condition of things is known as symbiosis or mutualism.

Very few fungi and flowering plants have attained to the condition of symbiosis, but a very remarkable instance has been shown to exist between a fungus and certain rye-grasses, *Lolium temulentum*, *L. perenne*, and *L. italicum*. In *L. temulentum*, the life-history has been worked out by Freeman. Briefly, the mycelium of the fungus is located in the 'seed.' On germination this mycelium becomes active and keeps pace with the growing stem of the grass, and continues to do so until it again enters the 'seed,' where it remains in a resting condition until the seed germinates, when the same cycle of growth is repeated. The presence of the fungus in no way interferes with the function of the seed, and experiments showed that infected plants were more vigorous and robust than uninfected ones. So complete is the symbiosis, and so certain is the fungus of perpetuating itself by the vegetative method described, that the production of spores or fruit of any kind has been arrested; consequently, we have no means of determining with certainty the affinities of the fungus. From this it follows that no infection of other plants of the same kind can occur. We have two distinct races of each of the three grasses: one race infected and always producing infected seed, so again the disease has become constitutional. A second race is free from disease, and without the possibility of becoming infected. A microscopical examination of a commercial sample of the seed of *L. temulentum* showed that over eighty per cent. were infected, hence the facility for

world-wide dispersion of diseased darnel, rye-grass, and Italian rye-grass is ample.

Many of the 'rusts' have permanent mycelium in the root or rhizome of the host-plant, which ensures the continuation of the fungus without reinfection by spores, and also ensures the introduction of the disease into a new country, if roots or rhizomes are introduced.

It has recently been proved that the mycelium of the rust fungi attacking cereals persists in the leaves as long as the plant lives, and produces uredospores during warm periods that occur throughout the winter months. In cold countries a very few degrees above freezing-point is sufficient for the formation of uredospores. In the spring there is usually a final outbreak of rust on old plants that have survived the winter, and the spores thus produced infect the spring crop, and so commence the disease afresh.

Many other examples could be given where a parasitic fungus has perennial mycelium located in some part of its host, but perhaps sufficient evidence has been furnished to indicate the facility with which fungus diseases can be introduced into a new district quite independent of fungus spores, and in a manner that defies detection otherwise than by microscopic examination.

When plants are introduced into a new country they are rarely attacked by the fungi indigenous to that country. This at first sight appears somewhat remarkable, but when it is remembered, as I have already explained, that most of our destructive parasites have become so highly specialised as only to be capable of infecting a single kind of plant, or at most a few closely allied plants, the reason becomes apparent. The following interesting fact illustrates this point. Pelargoniums were originally introduced into this country from South Africa; during their stay with us they have not been attacked by the rust so common on our wild geraniums. Quite recently a selection of the best varieties was returned to South Africa, where they were promptly attacked by *Puccinia granularis*, the rust common on pelargoniums in South Africa.

One marked exception to this rule has occurred in the case of the very destructive coffee disease. When this plant was introduced into Ceylon it was attacked by an indigenous rust (*Hemileia vastatrix*), that occurs on two or three plants belonging to the coffee family. So destructive did the

parasite become that the cultivation of coffee had to be abandoned. At a later date coffee plantations have been established in Natal and German East Africa, but the same kind of fungus has proved destructive there also, and on investigation it has been shown that the *Hemileia* is also present on native trees in Africa belonging to the coffee family.

FACTS NOT GENERALLY KNOWN

However frequently and however well spraying is done, it should always be considered as nothing more than a supplementary aid towards the prevention of disease. Take, for instance, the too well-known scab of apples and pears, for the prevention of which spraying is perhaps more generally practised than for any other disease in Britain. The fact has now been generally accepted that this disease is caused by a fungus, hence many people commence by spraying the quite young fruit, for the purpose of destroying the fungus spores that alight on its surface. Other people, possessing a little more knowledge on the subject, spray the young foliage some time before the fruit is set, knowing that as a general rule, the fungus appears on the leaves before it does on the fruit, and that it is the spores produced on the leaves that are washed by rain, etc., on to the young fruit. This is one step in advance, but not sufficient. How many people know, or if they know, act on the knowledge that the fungus first forms spores on dead terminal shoots, that the spores formed on such dead twigs infect the young leaves, and from thence pass to the fruit. Now no amount of spraying will kill the mycelium of the fungus present in the dead shoots, hence some other remedy is necessary. Such remedy is only to be found in the removal of all dead tips of shoots during the winter, before the spores are produced. As a further safeguard, spray just when the leaves are expanding, as it may safely be assumed that certain infected branches have been overlooked.

Black scab or warty disease of potatoes is perhaps more destructive than the original 'potato disease' caused by *Phytophthora infestans*. Yet many people collect diseased potatoes and throw them into the piggery, realising that the pigs may benefit a little by eating them. Probably the pigs do benefit to a certain extent, but if the owner knew that the spores present in the scabbed potatoes passed through the

intestinal canal uninjured, were conveyed along with the manure to the land in a condition to infect future crops of potatoes, perhaps he would come to the conclusion that it would be a far more economical method to burn, or in some manner thoroughly destroy such diseased potatoes, than to run the risk of infecting previously clean land, and have diseased crops in the future.

With the idea of making the best of a bad job, it is the usual thing to throw diseased roots of all kinds that can be eaten, turnips, carrots, mangolds, potatoes, etc., into the piggery or cattle shed. The statement made above respecting the spores of the black scab fungus is true of all cases. The spores to a great extent find their way back to the land in manure, and consequently diseases are—unconsciously on the part of the farmer—perpetuated.

I am perfectly well aware that in many instances the return of the spores of fungi to the land cannot be prevented, nevertheless it is just as well to know the worst. In the case of wheat mildew, caused by *Puccinia graminis*, D.C., the last, or teleutospore, stage has its spores so firmly attached to the straw on which it grew, that they are not removed by the operations of harvesting, threshing, etc., and may often be found, when specially looked for, on fragments of straw in the manure heap. Such spores are capable of germination, and if the minute secondary spores they produce alight on the right host-plant, the disease commences its cycle of development.

When land has produced a crop of potatoes affected with black scab, or of turnips injured by 'finger-and-toe,' it is perfectly certain that some of the spores will remain in the soil. Here again, prevention of infection of neighbouring land is a much more difficult matter than might at first be imagined. Soil containing spores from the infected land may be conveyed to adjoining clean land on various implements, cart-wheels, boots, etc.

As a rule parasitic fungi attack only one particular kind of plant, or at most, a few closely related kinds of plants; consequently when a diseased crop of potatoes has occurred, potatoes should not be planted in the same land again for some years. By adopting this method, the spores present in the soil, and capable of infecting potatoes, may perhaps perish in the absence of the proper host-plant. The black scab fungus, so far as known, can only attack potatoes. 'Finger-

and-toe,' or 'anbury' can only attack cruciferous plants, turnips, cabbages, etc. Corn mildew never attacks plants of economic value, outside the various cereals. The above statement naturally suggests, in the case of land known to be infected by some particular fungus, the sowing of some crop that cannot be attacked by the fungus known to be present in the soil. This again means simply rotation of crops.

In connection with this subject, it may be pointed out that a given disease is much favoured in its extension, when great numbers of its host-plant are crowded together. Here again it is in most instances practically impossible to avoid growing large areas of the same kind of plant, as in the case of crops generally, cereals, turnips, potatoes, etc.

On the other hand, in some cases, trees of one kind only are planted over a large area, especially larch-trees, whereas if the wood consisted of a mixture of larch and other suitable trees, the very destructive larch canker, caused by *Dasyscypha calycina*, would be to a very considerable extent checked in its career, and would not assume the proportions of an epidemic.

In many gardens and fields there is a corner reserved as a dumping ground for rubbish in general, which in too many instances is allowed to accumulate from year to year. Such an accumulation of decaying vegetable matter serves as a veritable hot-bed and nursery for many kinds of fungi, as is proved by the presence of a considerable quantity of mould and mycelium present, if the mass of decaying matter is disturbed after six months' rest. Among other fungi *Botrytis cinerea* is almost invariably present on decaying vegetable matter, and this is one of the most universal and destructive of fungus parasites known. Undoubtedly many local epidemics originate from spores produced on such accumulations of dead and decaying plants. At the same time it is necessary that plant remains should be collected somewhere, but to prevent danger, and at the same time enhance the value of the manure resulting from such accumulations, a judicious sprinkling of lime or, better still, gas-lime, would prevent the copious growth of fungi.

I have on previous occasions stated that weeds of various kinds growing on neglected borders of fields, headlands, hedgerows, etc., harbour many kinds of fungi that are capable of infecting the particular crop that may be growing

in the field. More than this, I have proved, on more than one occasion, that a fungus disease which has proved destructive to a crop has originated in the first instance from spores produced on weeds growing on the borders of the field. A celebrated professor of agriculture, hailing from one of our universities, has pronounced the above statement to be a mycological myth, adding as a rider, that it was impracticable to keep headlands, etc., clear of weeds. As to whether it is practicable to keep headlands clear, or even as to

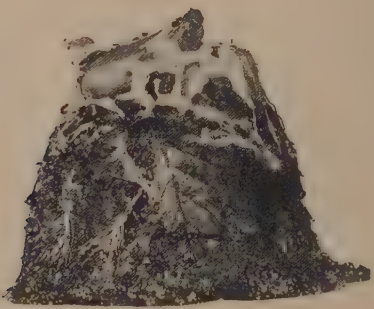

FIG. 1.—Leaf mould infested with mycelium, turned out of a plant pot, in which a Begonia was planted. The mycelium attacked the root of the Begonia and killed it. Reduced.

whether it is necessary to have uncultivated headlands at all, I leave for the practical farmer to decide.

Some years ago, a batch of begonias that had been potted in leaf-mould went 'off' in a mysterious manner. On investigation it was discovered that the leaf-mould in which the begonias were planted was overrun by a dense mass of white mycelium. As a rule leaf-mould contains mycelium, and in this particular instance the mycelium or spawn of some fungus proved predominant. This is only an isolated instance of the destructive work done by fungus mycelium present in leaf-mould. It can be prevented by intimately mixing a small amount of kainit with the leaf-mould some time before it is used.

WOUNDS

Wounds may conveniently be arranged under two distinct headings: (1) natural wounds, effected by the plant itself for economic reasons; (2) wounds resulting from outside influence, as pruning, birds, game, insects, storms, grass-cutting machines, etc.

Self pruning.—Many different kinds of trees shed certain of their twigs annually, as the litter of twigs under such trees

FIG. 2.—An example of good pruning. The wound was at once protected by a coating of gas-tar, and is nearly covered by a development of callus. The figure represents portion of a poplar growing in Kew Gardens. Much reduced.

clearly indicates. The plant anticipates the fall of certain branches some time in advance, by forming a layer of periderm across the branch at the point where the portion no longer required is to be cut off, so that when the twig actually

drops off the wound is already healed and closed against infection by fungus spores, etc. In some instances a deposit of gum at first spreads over the wound, and the production of periderm follows by degrees. Such wounds are natural, and do not expose the tree to those dangers that follow artificial wounds, over which the tree has no control, and for which it was not prepared.

Amongst trees that annually shed some of their twigs are, oaks, poplars, willows, elms, horse-chestnuts (*Catalpa*, *Ailanthus*), etc.

Gager, *Journ. N. Y. Bot. Garden*, 8, p. 252 (1907).

Pruning.—My only object in mentioning this subject is to indicate the great risk of injury following an improper method of pruning. If a branch is properly removed the wound is in course of time protected by a callus, but before this protection is completed, even under the most favourable conditions, the spores of fungi may alight and germinate on the wounded surface, enter into the tissues, and start a disease which can never be eradicated. On the other hand, if a branch is improperly removed, a callus may form only in part or not at all, and the danger indicated becomes almost a certainty.

The advice of those best able to speak with authority is: prune trees as little as possible.

Hartig says: 'The rate at which a wound is occluded [=protected by a callus] depends entirely upon the vigour of the tree and the size of the wound. A callus forms on young trees, with their relatively broad annual rings, faster than upon old trees, and the faster, too, the higher on the stem the wound is situated, because with few exceptions the breadth of the rings increases as we ascend. It is equally apparent that occlusion will be accomplished sooner where the situation is good than where bad. In the case of dicotyledonous trees, especially the oak, branches of a greater diameter than four inches should not be removed.'

Schlich says: 'As a general rule plants should not be pruned unless it is absolutely necessary. Every cut produces a wound, exposing the plant to disease, which may ultimately render it unfit for the purpose for which it has been grown. Recent researches have shown that the unhealthy condition of timber trees may be due to the spores of fungi entering the tissues through wounds received at a very early age.'

Notwithstanding the above, pruning is sometimes necessary, even on a large scale, as in the case of trees growing in streets, etc., and it is important that it should be performed in a manner incurring the minimum of risk of infection by fungus spores, or of decay of the wounded portion through wet.

A general rule is that a branch should be cut as close as possible, and the cut should be parallel to the part from which the branch is removed. This method of operation is most favourable for the quick development of a callus, provided the edge of the bark surrounding the wound is not crushed or torn in removing the branch. As soon as possible after the removal of a branch, the wounded surface should be thoroughly covered with a coat of gas-tar.

Pruning should always be done during the autumn or winter months, if undertaken in spring or summer the gas-tar fails to enter the wood, and does not prevent the entrance of spores and wet into the tissues through cracks that form in the wood during drying.

Mr. J. Bean, assistant curator, Kew Gardens, has recently published a valuable article on pruning, illustrating right and wrong methods, in the *Gardeners' Chronicle.*

Bean, *Gard. Chron.* (1905).
Hartig, *Diseases of Trees* (Engl. ed.), p. 257 (1894).
Schlich, *Manual of Forestry*, 3, p. 283.

Injuries caused by man.—As previously stated, grass-cutting machines do a great amount of injury to the exposed roots and bases of trees when carelessly handled. Such injuries are usually either altogether ignored, or simply covered with soil to hide the injury.

During the planting of young trees the collar of the stem is often more or less barked or bruised by the boots of the workmen stamping the soil down round the root.

In both these instances the wounds made serve as openings for the attack of wound fungi, and when young larches are injured in planting, larch canker too frequently follows in due course.

Injuries caused by wind, snow, etc.—Too frequently limbs of trees are broken by wind or by the weight of snow resting on the branch. When such accidents happen to trees it is desirable to preserve, the wound made should be carefully

trimmed and the hole filled with cement to keep out wet and fungus spores, otherwise the tree will soon become decayed and hollow.

DROUGHT

Stagheaded trees.—This disease is indicated by the topmost branches of the crown dying, the dead branches showing conspicuously above the general mass of foliage. The injury is due to lack of water, which implies a shortage of food-material, and the upper branches are starved, the lower ones monopolising all the water and food. This may be owing to prolonged drought, excessive drainage, or to any surrounding conditions affecting the underground water-level. It is more frequently due to the removal of litter or thinning or removal of the undergrowth. Hartig says that 'when oaks that have grown up in a dense wood of beeches, and that have but poorly developed crowns in consequence, are isolated by the removal of the beeches, they clothe their stems abundantly with epicornic branches. For some years these, as well as the crowns, thrive perfectly satisfactorily. In the process of time, however, and especially on the lighter classes of soil which are subject to rapid drought or are liable to produce weeds, a portion of the topmost branches of the crowns die, and the oaks become stagheaded. If the ground is protected in time by under-planting, the top branches either do not die or the disease fails to make any progress, and the stagheaded condition may entirely disappear owing to the dry branches dropping off.'

Hartig and Somerville, *Text-Book of Diseases of Trees*, p. 270 (1894).

INJURIES DUE TO FROST AND HAIL

Spring frosts.—When frost occurs late in the spring many plants suffer from its effects that have survived without injury more severe frost during the winter. This is owing to the fact that during the winter, when the plant is not vegetatively active, or before its leaves have expanded, the amount of water in those parts most susceptible of injury is comparatively small, whereas when active growth has commenced, the leaves and youngest shoots contain a considerable quantity

of water, and it is the freezing of this water that is the cause of injury under certain conditions. What happens is briefly as follows. During a late spring frost water is abstracted from the cells into the intercellular spaces, and more especially under the epidermis of leaves and shoots, where it freezes

FIG. 3.—A 'stag-headed oak' growing in Epping Forest. (A. Clarke.)

into parallel prismatic crystals. This withdrawal of water from the cells of a leaf causes it to droop and exhibit the well-known symptoms of the effect of frost. If thawing takes place slowly, so that the water can be again absorbed by the cells, the leaf gradually becomes erect, and no lasting injury

is experienced. On the other hand, if thawing takes place rapidly, the liberated water escapes into the intercellular spaces instead of being absorbed by the cells, and the death of the organ results. From the above account it follows that when plants have been frozen late in the spring they should be protected by a covering of some kind from the sun's rays, so that they may thaw gradually and slowly. When the covering method is impracticable, a thorough syringing with cold water is often effective in preventing rapid thawing.

When actively growing leaves are frozen late in the spring, the epidermis of the under surface is often completely torn away from the rest of the leaf, and hangs like a blister. I have seen a whole field of cabbages affected in this manner, with the large lower leaves hanging limp on the ground, and the lower epidermis raised in large blisters. The young leaves of *Aucuba* and other evergreens also suffer in a similar manner.

Frost cracks.—These are longitudinal cracks of variable length in the bark and wood of tree trunks, and are generally the result of a sudden and great reduction of temperature. The cracking is due to the abstraction of water from the cell-walls, which freezes in the cavities of the cells. Owing to this loss of water from the walls the cells shrink and a crack is the result. When the temperature rises the cells expand by again absorbing water, and the crack closes up more or less, and is soon protected by a growth of callus along the two edges of the wound, which projects more or less above the level of the adjoining bark, and is known as a 'frost-rib.'

In some instances a frost-crack that has healed up is again opened by frost, when the same healing process is repeated. If this rupturing occurs repeatedly a very prominent frost-rib results, which may finally remain permanently open or closed depending on weather conditions.

Catalpa bignonioides, an ornamental tree, is a native of the southern United States, and is often injured by frost when planted in the New England States, and in this country. A very fine specimen, about sixty years old, recently succumbed from frost in Kew Gardens. The tree had two tiers of principal branches, an upper tier of four nearly horizontal branches and lower down on the trunk three larger ones. When the upper branches were about forty years old, each one was injured by a severe frost, which produced a frost wound throughout its entire length. These wounds never

healed, as shown by the accompanying figure, and afterwards no more branches were formed on the upper side of these branches, and only comparatively few on the lower side; as a result these four branches were literally starved to death, owing to lack of food and water. The three large lower branches, being sheltered by the upper ones, were perfectly healthy and bore an abundance of foliage and flowers when the tree was cut down.'

Glassy fir is the name given by Schrenk to the appearance of glassy or polished portions of the trunk of the balsam fir (*Abies balsamea*), when cut with a cross-cut saw. These portions are perfectly smooth and shiny, as if they had been planed, and are conspicuous as contrasted with the normal roughened surface produced by the saw. Some of these patches extended from the heart to the sap-wood, others formed irregularly circumscribed spots usually surrounding healed-over portions of old branches. Where the patches were isolated they were generally near some check. In all cases the sap-wood had the glassy appearance. All the specimens examined were cut during the months of February and March, when the temperature was 32 F., or much lower.

A series of experiments showed that the glassy appearance was due to the presence of frozen water in the wood. Wherever the wood-cells were filled with ice the saw made a clean polished cut, and the fibres were not torn as is usually the case, the ice acting like imbedding material, paraffin, etc., in sustaining the weak cell-walls during the operation of cutting sections. In cooling, the sap-wood just within the bark would freeze first, and the cooling would gradually extend inwards, hence the sap-wood presents a uniform glassy appearance. The distribution of glassy patches along the lines of former branches is accounted for by assuming that the lowering of the temperature would take place more quickly along such channels as are in communication with the outer portions of the trunk.

From a practical lumbering standpoint, glassy fir cannot be considered as a defect, as it has been in some instances before its origin was clearly known.

Schrenk, H. Von, 'Glassy fir,' *Sixteenth Ann. Rep. Missouri Bot. Gard.* (1905).

Injury caused by hail.—The amount of damage to leaves and flowers caused by hail is well known. The fact that an equal or greater amount of damage to the bark of trees, especially when the rind is smooth, is occasioned by hail is not so generally realised. . Hartig states: 'At places where the hailstones strike, the rind is crushed, or, it may be, knocked off altogether. Although as a rule a callus very soon forms over such wounds, still it not infrequently happens that the injured portion of the stem dies. In young spruce woods in the neighbourhood of Munich I found that the leading shoots which were affected by hailstones died—a result doubtless due to the excessive evaporation from the wood, which in many cases was stripped of its cortex on one side of the shoot to the distance of about an inch.

'It very frequently happens that the wounds caused by hailstones form an entrance for parasitic fungi. The spores of *Nectria ditissima* are specially apt to germinate on such places, and to produce canker on the beech. Larches, too, are often similarly infected by *Peziza willkommii* (=*Dasyscypha calycina*).'

In the winter of 1907 a pear-tree was badly injured by hail, and the accompanying illustration shows portions of a branch of the injured tree as it appeared during the winter of 1908. Immediately after the storm the cortex was seen to be bruised in those places struck by the hailstones, at a later date those bruised portions died, contracted, and separated more or less from the surrounding living tissue. In some of the cracks thus formed various kinds of fungi had established themselves.

Injury by hail can generally be recognised by one side of the branch only being damaged, the sheltered side remaining sound.

Hartig and Somerville, *Diseases of Trees* (Engl. ed.), p. 299 (1894).

CHLOROSIS

This term is used to express the gradual disappearance of the green colouring matter—chlorophyll, from leaves. In some instances this loss of green colour extends over the entire surface of the leaf, in others only patches disappear here and there, giving the leaf a variegated appearance.

Such diseased leaves, and sometimes also young shoots, first change colour to a sickly greenish-yellow, and then assume a clear yellow colour, finally becoming almost white and drying up. The disease is of frequent occurrence and attacks plants belonging to widely separated families. The disease

FIG. 4.—Two portions of a branch of a pear-tree damaged by hail. The left-hand figure shows the injured side of the branch; that on the right hand shows the uninjured side. Half nat. size.

has been studied in detail by Viala, as affecting the vine. When once attacked, the branches, although yellow, do not die at once, but produce leaves which remain small and are of a yellow colour. The branches produced are numerous, very short, slender, and bear only rudimentary leaves. If the disease occurs during the flowering season, the colour of

the flowers is changed and the fruit remains small and yellowish, with scattered reddish patches, and finally shrivels. The root presents a normal appearance superficially, but when carefully examined the vascular system is found to be feebly developed, the amount of protoplasm is scanty in the cells, and there is but little nitrogenous material present. In the leaves the chlorophyll not only disappears, but also the chloroplasts. In such leaves raphides and crystals are very abundant.

The primary cause of chlorosis is not definitely known; Viala strongly suspects the presence of carbonate of lime in the soil as the agent. The disease only manifests itself in vines growing in a calcareous soil. It is considered that the carbonate of lime taken up in solution by the roots precipitates the organic acids in the cells, and owing to this precipitation, the carbonate of lime continues to be taken up by the roots. By this means the normal acidity of the cell-sap is diminished, and the normal feeble alkalinity of the protoplasm is augmented. As a consequence the normal activity of the cells is disturbed, and results in a diminished formation of nitrogenous matter and of hydrocarbons. Viala further demonstrated that the application of sulphate of iron restored the green colour. The ground was watered in the spring with a solution of sulphate of iron in water.

The sulphate of iron is supposed to act by converting the soluble carbonate of lime into insoluble sulphate of lime—gypsum.

Watering the foliage with one per cent. solution of sulphate of iron in water also favours the formation of chlorophyll in the leaves.

S. Mokrzecki has recently been experimenting with sulphate of iron as a cure for chlorosis; the following is his account of the process and the results attained.

In order to restore the trees to health, I bored from one to four holes in the trunk of the tree, 1 to 1½ cm. in diameter, and deep enough to put 4 to 12 grammes of green vitriol (sulphate of iron). These holes were smeared over with cement. These little wounds readily heal towards the autumn. The ascending sap carries up with it the iron in solution to the tips of the leaves, and the trees begin to improve wonderfully; the bright green colour soon appears, and in size and any other relation it is difficult to distinguish them from those not affected. Other salts of iron (such as

the phosphate and chlorate) do not affect the cure so readily. Spring (May) months are the most appropriate time for this operation. By this method I have effected a permanent cure on many hundreds of trees of different varieties, not excepting coniferous or evergreen trees. The deforming anthracnose of the grape-vine rapidly disappears under the influence of sulphate of iron, the leaves acquiring their normal size and colour. In other experiments of this internal method of nourishing the plants, not directly through the roots, by means of various combinations of salts, dry or in solution (using for this purpose a small and very simple apparatus) I succeeded in increasing their size and improving their colour, thus effecting a cure.

Mokrzecki, S., *Gard. Chron.*, Jan. 16, 1904, where reference to further literature by the same author is given.

Viala, P., *Malad. de la Vigne*, p. 430 (1893).

Contagious chlorosis.—Baur has shown that chlorosis of a contagious nature exists in certain members of the Malvaceae, also in *Ligustrum* and *Laburnum*, and is probably of widespread occurrence. The cultivated variegated mallows were derived from a form of *Abutilon striatum* called *A. Thomsoni*. This plant transmits its variegated condition by grafting. Baur discovered that if the leaves are removed from a variegated plant, or if the shoots bearing leaves are removed, and the plant is kept in the dark, the new shoots produce only very few variegated leaves, and if those are removed, the plant remains permanently green in the light, unless it is again infected by grafting scions of a variegated plant. If latent axillary buds of the old parts produce variegated leaves the whole plant is quickly infected. When scions of the immune *A. arboreum* are grafted on the infected *A. Thomsoni* they grow readily but do not become infected; whereas if scions of a susceptible kind are in turn grafted on the *A. arboreum* of the previous experiment, they become infected, thus proving that the virus can travel unchanged through the intermediate piece of *A. arboreum*. Shoots bearing green leaves that are immune to the disease sometimes appear on *A. Thomsoni*. If one of these shoots is grafted on a variegated plant the scion continues to produce green leaves. If in turn a susceptible scion is grafted on to the immune branch, its leaves are variegated, showing that the virus

passed through the immune branch. This passing of the virus unaffected through a portion of an immune plant does not always hold good. If a scion of *Lavatera arborea* is grafted on *A. Thomsoni*, and another susceptible portion is in turn grafted on the *L. arborea* portion, the leaves do not become variegated. In this instance the virus loses its potency in passing into the intermediate immune scion of *L. arborea*. The author considers that this form of variegation or chlorosis is due to the presence of a virus depending on light for its formation. When grown in the shade susceptible plants lose the variation and become green, although the general health of the plant is not affected. Experiments proved that the virus travelled in the cortex and not in the wood.

Baur, E., *Ber. d. deutsch. Bot. Gesells.*, 24, p. 416 (1906).

INJURY BY SMOKE, ACID FUMES, GAS, ETC.

Sulphur dioxide has been proved to be the specific cause of injury to vegetation arising from smoke. Wieler, who has recently investigated the subject in an exhaustive manner, states that, contrary to the view of von Schroeder and Rensz, sulphur dioxide, like other gases, enters into leaves only through the stomata. Leaves having the surface-bearing stomata coated over showed no injury, when exposed for several hours to a comparatively strong concentration of the gas.

In very young leaves the gas penetrates the cuticle.

The physiological effect of sulphur dioxide on foliage is very complicated. Probably its acid nature and its capacity for forming certain products with aldehydes present in the tissues act on the protoplasm. Wieler recognises two kinds of injury, acute and chronic. The acute condition is rare, and is manifested only in the immediate neighbourhood of the source of the smoke where the quantity of gas is sufficient to kill the tissues directly. In chronic cases, where the gas is present only in a very small percentage, respiration becomes irregular, photosynthesis is partly checked, probably due to the direct action of the gas on the chlorophyll rather than to the closing of the stomata. The removal of the products of photosynthesis is somewhat checked, and growth is retarded.

On the other hand transpiration is not affected by the presence of the gas, neither is the absorption of water interfered with.

Notwithstanding the deleterious effects indicated, Wieler does not consider them sufficient to account for the chronic form of injury, and is led to believe that the true cause will be found in the effect of the gas on the soil, and that such continuous accumulation of sulphur dioxide in the soil is responsible for all the injury due to smoke, the ultimate effect resembling death due to drought.

Haywood has investigated the action of smelter fumes. The ore consisted of sulphides of iron and copper. Practically all the sulphur in the ore is burned and given off into the air, principally as sulphur dioxide, but to some extent as sulphur trioxide. For each pound of sulphur burned two pounds of sulphur dioxide are formed and given off; this acts directly on the foliage. Sooner or later all the sulphur dioxide becomes sulphur trioxide, and in this form is found in the leaves. Sulphur trioxide becomes sulphuric acid in the presence of water, which also acts on the leaves. Within a radius of three miles of the forge all vegetation was killed, and even at a distance of nine or ten miles numbers of fruit-trees, especially peaches, which are very sensitive to injurious substances, were badly injured.

The author's conclusions are as follows:—

Sulphur dioxide, when present in very small quantities in the air, kills vegetation.

Such injury shows itself by the increased sulphur trioxide content of the foliage.

Finally it is stated that in connection with this study it might be of value to give some idea of the amount of sulphur dioxide that is given off each day into the atmosphere by the smelter. Analyses of three samples of the ore show that it contains 41·87, 40·06, and 42·44 per cent. of sulphur, or 41·46 per cent. sulphur on the average. Since in extracting the copper the sulphur is nearly all given off as sulphur dioxide, it seems safe to assume that 90 per cent. of the sulphur from this ore would be liberated. Therefore a simple calculation will show that for each ton of ore about 838 pounds of sulphur or 1676 pounds of sulphur dioxide would be given off into the atmosphere. The author has been informed that the smelter extracts 1000 tons of ore per day. If such is the case it will be seen that the enormous quantity of 1,676,000

pounds of sulphur dioxide (or 748 tons) are given off each day.

Placing sulphur on hot-water pipes is always a risky experiment, and sometimes results in disaster. The above account explains how this is brought about. If the heat is above a certain point some of the sulphur at all events is converted into sulphur dioxide; this in the presence of moisture eventually becomes sulphuric acid. Both these substances are extremely injurious to plants.

Coal gas. — The leakage of gas from faulty pipes often causes considerable injury to plants. The roots of trees are completely dead and rotten before the cause of injury is suspected. In such cases the bark of the trunk becomes dry and frequently falls away in large patches. Mr. Aggett, Superintendent of Public Gardens, Bermondsey, who has had much experience of the injury caused by the leakage of gas in the seventy miles of streets under his supervision, states that after trees had been killed by gas in the soil, when a space of six feet square of the affected area was cleared and replaced with new soil (after the pipe had been repaired), the young trees perished, and it occurred to him to place a lining of wet clay over the sides and bottom of the hole, and the result proved in every way satisfactory. Unless this precaution is taken, two or three years must elapse before the gas has completely escaped from the soil.

Creosote fumes.—During recent years since wood-paving has been introduced, the fumes from the creosote used for dressing the blocks has proved disastrous to vegetation. Bedding plants of all kinds are promptly blackened, shrivelled, and killed, and the foliage of trees is also destroyed or severely injured.

Aggett, W. H., 'Trees affected by gas,' *The Garden*, 60, p. 246 (1906).

Haselhoff, E., and Lindau, G., *Die Beschädigung der Vegetation durch Rauch* (1903).

Haywood, J. K., 'Injury to Vegetation by Smelter Fumes,' *U.S. Dep. Agr. Chemistry, Bull.* No. 89 (1905).

Wieler, A., *Untersuchungen über die Einwirkung schwefliger Säure auf die Pflanzen* (1905).

INTUMESCENCES AND WARTS

These structures frequently occur on the surface of leaves or on young shoots, and may be due to the work of mites or insects; on the other hand they may appear as the result of special conditions of temperature, moisture, etc., or again they may be directly produced by the application of some chemical stimulant, as in spraying. Those cases resulting from the influence of some physical agency will only be dealt with here.

In this country such small warts are most frequently met with on the under surface of vine leaves grown under glass. It is generally agreed that excess of temperature and humidity favour the formation of these growths. Opinions differ as to the part played by light in the process. Sorauer and Atkinson consider that a dull light favours the formation of intumescences, whereas Dale states that white light, more especially yellow and red rays, are absolutely necessary for their formation. Viala and Pacottet also state, as the result of experiments, that intumescences are caused by an excess of light in a damp atmosphere, and that it is only during a period of bright light, and only on leaves near to the glass that these structures are formed in quantity, being practically absent from leaves growing in diffused light or in the shade. These authors consider that shading the glass would prevent the formation of warts by checking excessive transpiration. Atkinson, on the other hand, considers that their presence may be due to the greater turgescence of the leaves owing to the low rate of transpiration in a gloomy greenhouse. It is evident from the foregoing statements that the part played by light in the formation of warts is by no means settled. Its direct action, if of any importance at all, may vary with different plants.

Sap warting.—This is a term used by gardeners to express the appearance of small ruptures and corky outgrowths in the bark of the stem or branches, which are sometimes continued along the midrib and veins of leaves. At first the ruptures are scattered and might be mistaken for lenticels, but usually they continue to increase in number until the branch is almost covered with small, gaping cracks with raised edges, and showing the inner pale cells of the bark in the central

portion of the wound. This form of injury is mostly present on plants grown under glass, and is especially common on

Fig. 5.—Intumescences, or sap-warts on stem of an *Acacia* grown in a hot-house. Nat. size.

species of *Solanum* and allied plants. It is, however, also met with on other plants, as species of *Mimosa*, *Acacia*, *Camellia*, etc. It is occasionally observed on plants growing outside,

but is not common, and must not be confounded with the excessive growth which gives a rugged appearance to stems, as in *Acer campestre*, the lower portion of the stem of *Lythrum* when growing in water, etc., although the latter examples may probably be the outcome of causes similar to those grown in houses, which in both instances consists in the formation of a mass of suberised or corky tissue composed of very large, thin-walled cells containing air. In the case of plants grown in warm houses, it is known that 'sap-warting' is favoured by an excess of heat and moisture, and is quite independent of the influence exercised by fungi or insects. In some cases, as in acacias, a certain amount of gum is produced, due to the breaking up of cells in the ruptures; this gum serves as a starting-point for the development of species of *Botrytis*, *Cladosporium*, and other minute fungi, whose mycelium eventually passes into the injured tissue, and sometimes also extends to the surrounding living tissue. Such fungi often intensify the original injury, but being in all instances wound-parasites and incapable of penetrating an unbroken surface, cannot be considered as the primary source of mischief.

Practically I have repeatedly noted that good ventilation, especially when applied in the morning, along with a reduction of temperature, checked the formation of warts on vine leaves. Such disfigured leaves are being constantly submitted for examination, with a query as to whether the warts indicate the presence of *Phylloxera*, the general appearance being the same in the two diseases.

Sap-warting yields also to the treatment indicated above.

Schrenk has recently described the formation of small warts on the under surface of cauliflower leaves, that had been sprayed with a copper and ammonium carbonate solution to check the progress of *Peronospora parasitica*. Various other copper sprays were also used, to which a small quantity of fish-glue was added to cause the spray to adhere more firmly to the leaves. In all cases the warts appeared a few days after spraying. Numerous experiments were subsequently made with sprays of different kinds on cauliflowers, and also with the various components of the solutions used separately. The following is Schrenk's summary.

1. Cauliflower plants sprayed with copper ammonium carbonate (5 oz. copper carbonate, dissolved in a mixture of 3 pints ammonia to 50 gallons of water) produced large numbers of intumescences as a direct result of the spraying.

2. Similar intumescences were produced by means of weak solutions of copper chloride, copper acetate, copper nitrate, and copper sulphate when sprayed in very fine drops on the surface of the leaves.

3. The intumescences were formed in larger numbers on the lower surface of the leaves than on the upper surface of the leaves.

4. Intumescences were formed independent of soil or atmospheric conditions, so that the heat and water supply had nothing to do with their formation.

5. Intumescences must be regarded as a result of the stimulating activity of chemical poisons, sprayed upon the leaf in weak solutions.

6. The stimulating activity exerted is due to the formation of compounds within the cells of high osmotic tensions, these compounds being either compounds formed by the copper salts with parts of the protoplast, or compounds formed as a result of a stimulus exerted, as evidenced by the presence of large amounts of oxidizing enzymes as a result of indirect stimulus exerted by the salts upon the leaf surface.

In all instances the general morphology and structure of these warts, independent of relative size, is the same. A section through a young wart shows certain of the cells forming the spongy parenchyma much enlarged, growing outwards, and raising the epidermis, which at a later stage becomes ruptured. The enlarged cells increase enormously in size and grow outwards, forming a wart projecting considerably above the general surface of the leaf. These giant cells are very thin-walled, the outermost ones only containing air, the more deeply imbedded ones containing considerably reduced chlorophyll grains. At first the cells forming the spongy parenchyma are only involved in the formation of the wart, but at a later stage the cells of the palisade tissue also begin to increase in size and become much elongated in the direction of the projecting portion of the wart. Reagents show that the older cells of the warts are more or less suberised and liquefied, and become broken up into a scurf-like mass.

Atkinson, G. F., 'Oedema of Tomato,' *Bull. Cornell Agric. Exp. St.*, No. 53 (1893).

Dale, E., 'Investigations on the Abnormal Outgrowths, or Intumescences on *Hibiscus vitifolius*,' *Phil. Tran. Roy. Soc., Ser. B*, 194, p. 163 (1901).

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Sorauer, P., 'Intumescenzen bei Solanum floribundum,' *Zeit. für Pflanzenkr.*, 7, p. 122 (1897).

Sorauer, P., 'Intumescenz an Blättern,' *Zeit. für Pflanzenkr.*, 8, p. 291 (1898).

Sorauer, P., 'Über Intumescenzen,' *Ber. d. deutsch. Bot. Ges.*, 17, p. 456 (1899).

Sorauer, P., 'Intumescenzen an Blüten,' *Ber. d. deutsch. Bot. Ges.*, 19, p. 115 (1900).

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FASCIATION

Popular names for this abnormal method of growth are 'sports,' 'freaks,' 'monstrosities,' etc., all implying the fusion or cohesion of stems or flowers which under normal conditions would have remained distinct. I am quite well aware that such terms as normal and abnormal are considered as out of date, nevertheless I think they make clear the idea I wish to convey. The following account is mainly after Worsdell, who has for many years paid special attention to this subject. The primary cause of fasciation remains to be discovered; in the majority of instances it is induced or favoured by a superabundance of food which in some way disturbs the equilibrium of the plant. On the other hand, it is by no means unusual to meet with fasciation of a single branch or flower of a plant, having all its other parts perfectly normal, thus proving that excess of food alone will not account for the phenomenon. Fasciation includes two distinct sets of phenomena—(1) the fusion of organs or tissues that were once distinct; (2) the branching of an organ or tissue which is primarily a unity. Fusion again is of two kinds, which it is most important to clearly grasp. (1) Postgenital, real or mechanical fusion; (2) congenital, or ideal fusion.

Postgenital fusion includes most of the sports or monstrosities with which we are most familiar, the commonest type being a flattening of the stem or peduncle, in which it is obvious that it consists of a number of structures grown together, which, under usual conditions, would have been

free from each other. When the equilibrium of an organism is upset there is often a tendency to *revert* in some of its characters to an ancestral condition, and flattened or strap-shaped fasciations are probably a reversion to an ancient type of branching. When our higher flowering plants, from some unknown cause, lose their balance, they revert to the long

FIG. 6.—A fasciated example of a cultivated carnation. Reduced.

past branching conditions of Lycopods, Ferns, and Algae. In these latter examples the branching is probably always primarily *in one plane*.

Congenital or ideal cohesion of parts is applied to those structures where cohesion occurs before development. The gamopetalous corolla is an illustration, having originated from the congenital fusion of primitively free petals, the free tips

and tube collectively constituting such a corolla. The fusion of stamens amongst themselves, as in *Hypericum*, etc., also fusion of stamens to petals, carpels fused to form a syncarpous ovary, all come under this head, which, according to the author, accounts for the great variety of form and structure met with in the plant world resulting in the varied combinations formed by cohesion of parts, or, on the other hand, the breaking up of primitive organs into a greater number of parts.

I have frequently been struck by the modification in form, structure, and durability of leaves produced on the clustered branches, more especially of conifers, called 'witches' brooms,' caused by fungi. Do such leaves represent a reversion to a more primitive type of leaf borne by the ancestors of the tree?

The following account of the origin of fasciation is given by Miss Knox, who investigated the causes and transmissibility, from generation to generation, of the banding or fasciation of stems in the evening primroses.

It was found that the malformations in question were due to injury in all cases examined. The injuries are caused by larvæ which hatch and feed on the growing tips, attacking the cells while still in a merismatic condition. In most plants which are attacked the growing region is destroyed or its vitality impaired, or the surrounding leaves alone are consumed, the cells of the apex not reached, when no fasciations result. Certain swarms of larvæ, by boring into the heart of the tip, inflict delicate wounds which may induce fasciation. The occurrence of the phenomena is dependent on three factors—the individual manipulation of the insect, the extent and nature of the wound, and the innate character of the plant. Slow-growing species are more apt to fasciate than those of rapid development.

In the case of fasciation from the rosette stage, the injuries may be made by small larvæ in the soil, and usually date from the first stages of germination. The development is slow, and all the causes must be traced far below any sign of their effect. The fasciations are ordinarily flat, but often ring-shaped, and intermediate stages between the two are common. The appearance of secondary meristems, which later differentiate and which may eventually become incorporated with the bundle ring, in conjunction with the alteration of the stem's shape, is a frequent occurrence.

The section of a fasciated tip shows no deviation from the normal structure other than that of shape. Below the fasciated region inequalities in the amount of wood formed are indicative of the early injury.

The progeny of fasciated plants shows no more tendency to fasciation than that of normal stock. Both may give an equally large percentage of fasciated stems.

Knox, *Fifth Year Book of the Carnegie Inst. of Washington*, p. 131 (1907).

Worsdell, W. C., 'Fasciation: Its Meaning and Origin,' *New Phytologist*, 4, p. 55 (1905).

BACTERIOLOGY OF THE SOIL

'Soil fertility, broadly interpreted, denotes the crop-producing power of any soil under given climatic conditions, and is itself the resultant of many forces often opposed to one another.' The above definition of fertility given by Voorhees and Lipman is terse and to the point, and the rider suggests with equal terseness the difficulties to be overcome in formulating in a concise manner the causes that culminate in such fertility.

The earliest scientific attempts to investigate the means whereby soil furnishes food for plants were undertaken by chemists, who, however, soon discovered that chemical methods alone would not solve the problem. Then followed researches from a physical standpoint, and much valuable information on soil-fertility is the outcome of soil physics.

At a still later period the part played by micro-organisms or bacteria in connection with the fertility of the soil was recognised, and it is now universally acknowledged that further progress bearing on the subject of plant nutrition will mainly result from the combined work of the chemist, physicist, and bacteriologist, and every scientific student of agriculture realises the supreme influence exercised by bacteria present in the soil on plant life.

It has long been known that poor, uncultivated land in process of time becomes capable of producing a good crop; in other words, such land increases in fertility. The following quotation from Hall bears on this point: 'How comes it that Geescroft land, with no plants growing on it which are capable

of fixing free nitrogen, has yet gained an enormous quantity of nitrogen during the twenty years under review, a quantity which at the lowest reckoning amounts to about twenty-five pounds per acre per year? The nitrogen brought down in the rain would account for perhaps five pounds per acre per annum, a little more will come in the form of dust, bird droppings, and other casual increments, while some may be due to the fixation of atmospheric nitrogen by bacteria in the soil not associated with leguminous plants, like the *Azotobacter chroococcum* of Beijerinck and Winogradski's *Clostridium pasteurianum*. The Azotobacter has been found abundantly in the Rothamsted soils, and in the case of grass land like the present the decaying vegetation would supply the carbohydrate which the bacterium must oxidize in order to fix nitrogen, it is quite possible that it may have effected considerable gains of nitrogen.'

Only recently has it become known that much of this increased fertility is due to the fixation of free nitrogen by bacteria present in the soil. These nitrogen-fixing organisms may be conveniently divided into two primary groups. (1) Free bacteria living in the soil; (2) Bacteria living in the root-tubercles of leguminous and certain other of the higher plants. It is only intended to briefly deal here with the members of the first group. The second group will be considered under the heading 'Bacteria,' p. 508.

Berthelot, a French scientist, was among the pioneers to indicate that gain of nitrogen in the soil was due to bacteria. Then followed the more exact investigations of Winogradski, Beijerinck, and others, which resulted in absolute proof being derived from pure laboratory cultures, that not only did certain bacteria possess the power of fixing free nitrogen in a form in which it could be directly utilised by the higher plants, but the particular species were isolated and their general characteristics accurately studied and described, so that they can be recognised with certainty by other bacteriologists. Among such species may be mentioned *Azotobacter chroococcum*, *A. agilis*, *A. vinelandii*, *A. Beijerincki*, *Clostridium pasteurianum*, *Bacillus mesentericus*, etc. At a later period it was discovered that the power of fixing atmospheric nitrogen was greatly increased when two or more species of bacteria worked in unison. It was further observed that the presence of certain substances in the soil greatly favoured the work done by nitrogen-fixing bacteria, while on the other hand their work is greatly retarded by the presence of other substances. Speaking

broadly, lime and sodium phosphate or calcium phosphate are highly favourable to bacteria of the Azotobacter group, and furnish respectively the calcium and phosphorus necessary for their existence.

It is important to bear in mind, that although exact research has established the fact that these organisms possess the power of fixing free nitrogen obtained from the atmosphere, when placed under favourable conditions, we are as yet very much in the dark as to what goes on in a state of nature; that is, we cannot as yet utilise these bacteria as a source of nitrogen on a scale necessary to meet the demands of those employed in the cultivation of plants.

The discovery by Oberlin that the application of carbon bisulphide to the soil greatly increased its fertility has opened up a new vista as to the great importance of bacteria in enriching the soil. Oberlin demonstrated that grape-sick soils could be rendered continuously fertile by the application of carbon bisulphide, thus abolishing the necessity for fallowing and rotation previously necessary. Much discussion followed this discovery as to the manner of its action. The explanation accepted at present is briefly as follows: The introduction of carbon dioxide into the soil at first results in the decimation of both the useful and injurious species of bacteria present. This results in the destruction or temporary retardation of the plants growing on the land, according to the amount of carbon bisulphide used. At a later stage a new bacterial flora appears in the soil, but there is a relative suppression of denitrifying forms, and a relatively rapid development of nitrifying bacteria, which results in the accumulation of nitrogen in a form readily available for plants.

It has been observed that when a crop of mustard is ploughed into the land green, its action is somewhat similar to that of carbon bisulphide on the bacteria present in the soil. It retards the development of acid-forming species, and favours the development of nitrifying species.

Among the difficulties to be overcome before we are in a position to utilise the abstract knowledge we possess, regarding those bacteria able to fix free nitrogen in the form of soluble nitrates, directly useful to plants, is the fact that there also exist in the soil bacteria capable of effecting an exactly opposite process. These are usually termed denitrifying bacteria, and their business in the scheme of nature

appears to be that of exercising the power they possess, of converting nitrates into nitrites, or ammonia, or of going to the extreme and liberating free nitrogen. The strong ammoniacal smell arising from a manure heap testifies to the presence of these organisms. An excess of farmyard manure in the field is acted on in a similar manner.

It may be regarded as practically certain that further investigation of this subject from a purely scientific standpoint will result in the discovery of methods that will be of the greatest value to all interested in the cultivation of plants.

Beijerinck, *Verslag K. Akad. Wetensch.* Amsterdam (1900-01).

Berthelot, *Chimie Végétale et Agricole* (1899).

Hall, *Journ. Agric. Sci.*, i. p. 241 (1905).

Oberlin, 'Bodenmüdigkeit u. Schwefelkohlenstoff'; Mainz, 1894. *Journ. Agr. Prat.*, 59 (1895).

Voorhees and Lipman, 'A Review of Investigations in Soil Bacteriology,' *U.S. Dept. Agr., Bull.* 194 (1907).

Winogradski, *Comp. Rend.*, 118, p. 353 (1894).

ECONOMIC ASPECT OF PLANT DISEASES

As a rule it requires nothing short of an epidemic to convince farmers and gardeners that a disease exists. During those seasons when the loss does not exceed three to five per cent., disease is considered to be absent, or if its presence is actually realised, it is only looked upon as a reminder that matters might have been much worse. This condition of things is most unfortunate; the three or four per cent. loss which undoubtedly occurs every year, and in every country, far exceeds, say during a quarter of a century, that due to sporadic epidemics. An epidemic appeals because there is a sudden, more or less heavy loss, due to an obvious cause, whereas when the same cause is at work in a quiet unobtrusive manner, the loss is not generally realised.

Comparatively few countries furnish statistics dealing with the loss caused by preventable diseases; whether this omission is due to indifference, ignorance, or diplomacy, remains to be ascertained.

From estimates furnished by the United States, Germany, Australia, etc., it is calculated that the annual loss on cultivated crops, caused by pronounced diseases or epidemics, ranges between £150,000,000 and £200,000,000. Probably double this amount would be a more accurate estimate if we take into consideration the constant loss occasioned on a scale too small to be recognised in preparing estimates.

Much of this loss could undoubtedly be prevented, but the methods adopted would require to be general and compulsory; in fact it is a work for the state and not for the individual to undertake.

The following figures will convince that the above statements are in reality more than suppositions, without any basis of fact.

The coffee-leaf disease in Ceylon caused a total loss amounting at the least estimate to £17,000,000.

In the United States, the following official statements have been made.

Wheat rust in one year amounted to $15,000,000.

Loose smut in oats $18,000,000, annually.

Bitter rot of apples, $10,000,000 annually.

Grape disease in two years amounted to $20,000,000.

A careful estimate furnished by the Prussian Statistics Bureau showed that in one year the loss from rust of cereals amounted to just over £20,000,000.

Australia experienced a dead loss of two and a half million pounds sterling due to wheat rust in a single season.

All the above represent loss due entirely to fungus diseases. The loss caused by insects is quite equal or even greater in amount.

FUNGICIDES

The term fungicide is given to the various solutions and powders applied to cultivated plants for the purpose of checking diseases caused by parasitic fungi.

A fungicide to be of practical use should possess the following points:—

(1) Destroy the parasite without injuring the host-plant.

(2) Easy to prepare and to apply.

(3) Cost moderate.

(4) Persist for some time in an effective condition on the plant.

(5) Non-poisonous.

Various fungicides have been boomed from time to time, but Bordeaux mixture, discovered by Millardet in 1885, is undoubtedly the best for use on an extensive scale. In addition to its acknowledged value as a fungicide, it is said in some instances, more especially in the case of potatoes, to prolong the life of the foliage, and thus favour the production of a heavier crop.

Bordeaux Mixture.—The essentials for the formation of this fungicide are, copper sulphate (blue vitriol), and milk of lime. Those two substances have from time to time been used in very different proportions in the preparation of the mixture. The general tendency during late years has been to reduce the quantity of lime, and the following proportions, known in America as the 'normal,' or 1·6 mixture, consists of:—

Copper sulphate, ...	16 lbs.
Quicklime, ...	11 lbs.
Water, ...	100 galls.

Place the copper sulphate in a coarse sack and suspend it until the sulphate is melted, just below the surface of a few gallons of water in a cask. In another vessel slake the lime gradually until it is reduced to a creamy consistency. When both are thoroughly dissolved, each should be made up to fifty gallons with water, then pour the milk of lime and the copper sulphate solution slowly together into one vessel, after which the liquid should be thoroughly stirred for five minutes. The usual test recommended for determining whether the solution is safe to use, is to place the blade of a knife in the liquid for a minute. If the blade becomes coated with copper, more milk of lime must be added, whereas if the blade remains unchanged, the solution is safe to use.

Although Bordeaux mixture has been in use for so long a period, the various modifications of its composition have been the result of rule-of-thumb methods, and it is only quite recently that the chemical side of the subject has been investigated by Mr. Spencer V. Pickering, F.R.S., of the Woburn Experimental Fruit Farm.

The result of this investigation has for the first time

enabled us to clearly understand in what particular way Bordeaux mixture acts as a fungicide, and also the special mode of preparation which results in the greatest amount of benefit, combined with the minimum amount of injury to the host-plant. The following is an abstract of that portion of Mr. Pickering's investigation that appeals to those desirous of preparing the most effective kind of Bordeaux mixture. Those desirous of understanding the why and the wherefore are referred to the original account, contained in the *Eighth Report of the Woburn Experimental Fruit Farm*, 1908.

The object to be aimed at in making Bordeaux mixture should be to reduce the lime to the lowest possible proportions consistent with the precipitation of the whole of the copper present; any excess of this means so much loss of efficiency, and so much money thrown away.

When milk of lime is used it is impossible to adjust the quantity so as to attain this end, but it is perfectly simple to do so by using clear lime water, and lime dissolves in water to the right extent to make Bordeaux mixture of very nearly 'normal' strength.

One hundred gallons of such a mixture is prepared as follows: Dissolve 6 lb. 6½ oz. of crystallised copper sulphate, by suspending it in a piece of sacking, in two or three gallons of water in a wooden or earthenware vessel. Take about three pounds of good quicklime and slake it in a little water, then put it into a tub with 120 gallons of soft water. Stir the lime and water, then leave it to settle until the liquid is quite clear. Run off 86 gallons of the clear lime water and mix it with the copper sulphate. This is a little stronger than 'normal' Bordeaux mixture. To reduce it to that strength, make up to 100 gallons with soft water.

However Bordeaux mixture is made, it is important to make sure that all the copper is thrown down. The most certain test that fruit-growers can use is to put a few drops of a solution of potassium ferrocyanide into a white saucer with some water, and to drop into this some of the clear liquid after the Bordeaux mixture has settled. A red or brown colour shows that there is copper in solution, and more lime-water must be added until the test shows no coloration.

Among the advantages in favour of thus preparing Bordeaux mixture are the following: Acting at once as a fungicide; whereas it appears to have been well established that ordinary Bordeaux mixture prepared with milk of lime has no fungicidal

action for a week or more after having been sprayed on the foliage. In the meantime it may have been removed by rain. Less danger of scorching, and no clogging of nozzles.

Pickering, Spencer V., F.R.S., *Eighth Report Woburn Experimental Fruit Farm* (1908).

Self-boiled lime-sulphur mixture.—This preparation, advocated by Dr. W. M. Scott of the *U.S. Department of Agriculture*, is a combination of lime and sulphur boiled with only the heat of the slaking lime, and is primarily intended for summer spraying, as a substitute for Bordeaux mixture, where the latter is injurious to the foliage and fruit, as in the case of the peach and certain varieties of apples. It is, however, distinctly stated that Bordeaux mixture is the better fungicide, and should be used except in those cases where scorching of the foliage or russeting of the fruit follows its use.

A satisfactory mixture consists of 8 lb. of good quicklime and 8 lb. of sulphur to 50 gallons of water. Place the lime in a barrel, and pour on a gallon of water to start it slaking, and to keep the sulphur off the bottom of the barrel. Then add the sulphur in a purely powdered state, adding more water to slake the lime into a paste. Considerable stirring is necessary to prevent caking at the bottom. After the violent boiling which accompanies the slaking of the lime is over, the additional quantity of water should be added to to make up fifty gallons, or at all events sufficient to check the boiling. Five to fifteen minutes are required for this process, according to whether the lime is quick acting, or sluggish.

Before commencing spraying the mixture should be strained through a fine sieve to keep back the coarse particles of lime, but all the sulphur should be worked through the sieve. When spraying, the mixture should be kept constantly stirred, otherwise it settles to the bottom, and is not evenly applied.

Paris green for the destruction of insects may be mixed when used for spraying apples, but as this substance is injurious to the peach it should not be used when this tree is sprayed.

Scott, W. M., *U.S. Dept. Agric., Bureau of Plant Industry*, Circ. No. 27 (1909).

Potassium sulphide solution.—This is commonly known as 'liver of sulphur,' and is often of use for checking the extension of a disease. It is of most use in houses and small batches of plants, but has no staying power on the foliage.

Potassium sulphide, . . .	1 oz.
Water, ...	2 to 3 galls.

The strength of the solution depends on the relative hardness of the foliage, and must be carefully tested. If used too strong the foliage will undoubtedly be scorched.

This solution loses strength by standing, and should not be prepared before it can be used at once.

Potassium Permanganate.—This is a useful fungicide at times for plants under glass, as it checks the progress of disease, and produces no discoloration of the foliage. It discolours paint. The material should be purchased in the form of crystals, which readily dissolve in cold water. A pale rose-red solution should be used.

Copper sulphate.—This salt used in the proportion of 1 lb., dissolved in 25 gallons of water, is an excellent winter wash for fruit-trees that have suffered from any fungal disease. The trees and surrounding ground should be thoroughly drenched. It is most important to remember that this wash should not be applied after January, as it completely destroys the foliage, and all spraying should be done before the leafbuds begin to swell.

Formalin.—This is a commercial name for a forty per cent. solution of formic aldehyde in water. It is valuable in destroying spores adhering to seeds, bulbs, tubers, etc., in the proportion indicated under the respective headings.

One pint of formalin in 30 gallons of water is a good proportion to use for soaking 'seed potatoes' as a remedy against the various forms of scab. The tubers should remain in the liquid for two hours.

For sprinkling grain to prevent smut, etc., use 1 pint in 50 gallons of water. Sprinkle the grain, mixing it at the same time, and leave in a pile for some hours.

Sulphur.—This is used in the form of a fine powder, and is one of the oldest of fungicides. It is most effective against the superficial mildews belonging to the Peri-

sporiaceae, as the hop mildew, pea mildew, etc. There are various contrivances on the market for depositing the powder on the foliage, which should be damp at the time of application. When required on a small scale, as for a row of peas, etc., 'flowers of sulphur' may be placed in a coarse canvas bag which is fixed to a pole, and dredged over the affected plants.

The following deal with spray mixtures generally, and give the mode of preparation of numerous different solutions used against fungi and insects.

Beach, S. A., Clark, V. A., and O. M. Taylor, *N.Y. Agric. Expt. Sta.*, *Bull.* No. 243.

Pickering, Spencer V., F.R.S., *Eighth Report of the Woburn Exp. Fruit Farm* (1908).

SPRAYING

In spraying plants the ideal to aim at is the production of a 'London fog' that settles on the foliage as a dense mist, forming minute particles of water that gradually evaporate, and leave on the surface of the foliage a uniform layer of the substance held in solution.

Spray solutions are preventive in their action, and not curative. They may check the occurrence or the extension of a disease, but they cannot cure a plant of a disease caused by a fungus, the mycelium of which is already in the tissues of the leaves. The object of applying a spray to a plant is to cover the surface of the foliage and other susceptible parts with a substance that will kill the germ-tubes of all fungus spores alighting on the surface of the leaves, etc., so that the mycelium cannot enter the living tissues. To effect this object every portion of the plant liable to infection should be covered with the fungicide. This is the goal, which has not been reached as yet. Some spraying machines, if properly handled, do much better than others, but I have never yet seen a spraying apparatus, however well managed, that produced the desired result, yet when spraying is done by an experienced hand, and with the machines now in vogue, an epidemic can be prevented.

The relative fineness of the spray depends mainly on two things: (1) The amount of pressure. A very much finer

mist-like spray is obtained with a pressure of 100 pounds than with a pressure of 70 pounds when the same apparatus is used. The 'power' sprayers used in the United States enable a much greater pressure to be easily and uniformly maintained than is possible with the hand machines mostly used in this country. In the United States spraying machinery has undoubtedly received most attention, and has reached the highest stage of perfection; steam, gasoline engines, and compressed air are used for the purpose of wholesale work over large areas of fruit orchards, etc.; by such means it is possible to spray the tops of the highest trees. (2) The deposition of a fine mist-like spray depends also very much on the kind of nozzle used. The worst type is where the water escapes as a solid rod-like stream, the spray being formed by the action of the air on the stream. Such nozzles convey the stream for a long distance, and are used when spraying high trees, but the stream is not broken up into fine spray however much force may be used, and a considerable proportion of the solution trickles off the leaves and does no good whatever. It is far more economical and effective to use a nozzle of the 'Cyclone' or 'Vermorel' type, in which a rotary motion is given to the liquid in a chamber just behind the outlet, and in consequence of which the stream emerges in a conical, fine spray. Such spray can be made to reach the top of a tree by means of extension pipes, or by rods.

Where Bordeaux mixture is used, some automatic arrangement should be present in the machine to keep the solution uniformly mixed, otherwise one portion will be too diluted to effect the desired object, and another portion so concentrated as to injure the foliage.

It proves most economical in the end to have all the pump fittings made of hard brass formed of copper and tin. Soft brass made of copper and zinc should be avoided, as it soon wears out and is corroded by ammonia, etc.

When fruit begins to ripen, spraying operations with Bordeaux mixture should cease, otherwise the fruit is liable to become spotted and consequently rendered unsaleable.

Lodeman, *The Spraying of Plants*. Macmillan & Co.

INJURY CAUSED BY NON-PARASITIC OR UNDETERMINED ORGANISMS

Lichens on fruit-trees.—Very frequently the trunk and branches of fruit-trees are covered with a dense growth of lichens of various kinds, which while admittedly adding to

FIG. 7.—*Usnea barbata* and *Ramalina fraxinea*, lichens growing on branch of apple-tree. Reduced.

their artistic appearance, are in other respects injurious, for although not true parasites, their presence prevents the bark, more especially of the younger branches, from performing its functions, and in addition forms a shelter for many kinds of

destructive insects. In tropical countries the evergreen, coriaceous leaves of many plants are attacked by truly parasitic lichens that form flattened, porcelain-like crusts, and when present in abundance prove injurious.

Spraying with a strong solution of Bordeaux mixture during the winter, when the trees are resting, completely destroys all lichens and mosses present on the trees. Even quicklime dusted on the trunk when wet from rain will kill the lichens present to a great extent.

Crown gall.—This disease appears to be very prevalent amongst fruit-trees of various kinds, also raspberries in the southern and central parts of the United States. The cause is not known, but some parasitic organism is suspected. The disease is characterised by the presence of rough knots or enlargements on the roots, usually just underground, but often on the smaller roots lower down, less frequently on the stem. The galls are distinguished from other similar swellings by the rough warted surface and more or less hemispherical form. On apples the galls are usually accompanied by a superabundance of fibrous roots. Such galls prove injurious in several ways; they interfere with the conduction of water and food materials when they occur on the main root, and they may cause the tree to produce fruit too young, etc. It has been proved by careful experiments that healthy plants of apple, peach, plum, and raspberry can be infected with galls taken from other kinds of trees, showing that the same organism is the cause of the disease on different kinds of trees.

The recommendations for its suppression are as follows:

Do not use seedling with 'hairy root,' or an excessive development of fibrous roots, or with indications of galls. In grafting, the disease may be communicated from diseased to healthy plants by the knife. Gall is more prevalent where the point of grafting is close to the ground.

Norton, J. B S.; *Maryland Agric. Expt. Station*, *Circular Bull.* No. 56 (1904).

Brunnisure.—A disease of vine leaves both in Europe and the United States; has been described as due to an organism named *Plasmodiophora vitis* (Viala and Sauv.). The Cali-

fornian disease is considered to be due to an allied organism, *P. californica* (Viala and Sauv.).

I have shown under the heading 'Orchid Spot,' that the supposed organism considered by Viala and Sauvageau as a member of the Myxomycetes, and named *Plasmodiophora*, is merely a diseased condition of the cells of the host-plant, and that brunnisure of the vine and 'orchid spot' are entirely due to physical causes.

Massee, *Ann. Bot.*, 9, p. 421.
Viala, *Malad. de la Vigne*, Ed. 3.
Viala and Sauvageau, *Journ. de Bot.*, 1892.

Strangling fungus (*Thelephora laciniata*, Pers.) is an exceedingly common fungus on heather tracts and in woods

FIG. 8.—*Thelephora laciniata*, a non-parasitic fungus growing up the stem and suffocating a young larch. Reduced.

and although not a parasite, it often proves highly injurious to young trees when first planted, by growing up the stem for some distance and enveloping the lower part of the seedling to such an extent that it is strangled or suffocated. The

fungus may frequently be seen growing up heather stems, it also spreads for a considerable distance on the ground. The general colour is brown, texture soft and fibrous, almost shaggy on the upper surface, wrinkled or papillose below, margin shaggy or torn.

Fairy-rings.—Several different kinds of fungi form the well-known fairy-rings, which often greatly disfigure and injure lawns, bowling-greens, etc. *Marasmius oreades* (Fr.),

FIG. 9.—Tuber of potato pierced by the underground creeping stolons of couch-grass (*Triticum repens*). Nat. size.

is a well-known offender in this respect, but species of *Tricholoma* and *Lycoperdon* also participate. When a fairy-ring once commences, it increases in diameter year by year, the mycelium constantly growing outwards into new ground, hence each season the crop of toad-stools is just outside the zone of ground occupied by the crop of the previous season. The mycelium obtains food partly from humus, and partly from the living roots of the grass.

Soak the ground thoroughly with a solution of sulphate of iron—one pound to a gallon and a half of water; for later applications, at intervals of a fortnight, use the solution at half the above strength. About three applications should suffice. It is important that the solution be applied when the soil is wet. If rain has not fallen the ground should be previously well watered. Lifting the turf with a fork enables the solution to penetrate the soil more readily.

The ground should be treated more especially just outside the evident ring, as that is where the living mycelium is located.

M'Alpine, *Bull. Dept. Agric. Victoria*, May, 1898.

Honeysuckle girdling trees.—The injurious effect of the honeysuckle in twining round and girdling the trunks of young dicotyledonous trees is too well known. The effect may be considered curious or ornamental, but if a given tree is required to be a source of profit, or even ornament, it should not, when young, be allowed to serve as a support for the honeysuckle.

Piercing of tubers.—Although scarcely to be ranked as a disease, and certainly not a parasite, it happens every now and again that potato tubers, carrots, etc., are completely pierced and grown through by the underground stolons of twitch or couch-grass—*Triticum repens* (L.).

Pine-apple heart rot.—Pine-apples from the Cape of Good Hope, sent to Kew for investigation, were found to show a blackening or browning of the axis of the fruit. In some instances the discoloration extended throughout the length of the axis, in others the central portion only was discoloured, the two ends remaining sound. A note accompanying the specimens stated that from January to April the fruit remained free from disease, whereas from April onwards –the commencement of the rainy season—a large number of pine-apples were diseased. The disease proved to be of a physiological nature, and caused by excess of moisture in the atmosphere which checked transpiration, thus preventing the translocation of substances in the tissues during the period of ripening. A similar disease occurs in this country when pine-apples grown under glass are exposed to an atmosphere almost saturated with moisture during the period of ripening. A heart-rot of apples of a physiological nature is reported from the United States, when the rainfall is excessive during the period of ripening.

No preventive measures can be suggested. It would be wise not to have pine-apples ripening during the rainy season. Externally there is not the slightest indication of the disease, which commences at the core, and gradually extends outwards.

Bitter-pit in apples.—This disease is of a physiological nature; the cause is unknown. It is known by the appearance of small brown spots in the flesh, most abundant at the calyx end of the fruit. The spots are at first most abundant just under the skin, but by degrees extend deeper into the flesh. After the outermost brown spots have existed for some time the tissue collapses, and the skin sinks at those points, so that the surface of the calyx end of the fruit presents the appearance of small-pox markings. I have investigated diseased apples from South Africa and from Australia, and the disease is probably present in greater or less quantity wherever apples are grown. A section through a brown spot shows the protoplasm dead and brown in the cells, and the starch is present in quantity, although it has disappeared entirely from the surrounding normal tissue that has begun to ripen. It is perfectly certain that the disease develops during transit in apples coming to England from South Africa, Australia, etc., and the calyx end of the fruit is most seriously injured, in fact in the majority of instances it is confined to that portion. So far as experiments have been made, the nature of the soil has no marked effect, neither has the absence or presence of manure of any kind tried. The general symptoms suggest the local presence of some substance that kills the cells, and prevents the transformation of the starch into sugar. The brown substance has sometimes, but not always, a bitter taste.

Massee, *Kew Bulletin*, 1096, p. 193; 1097, pp. 142 and 250.

'Spot' disease of orchids.—The very prevalent disease known to cultivators of orchids as 'spot' is characterised by the presence of somewhat sunken, brownish spots or patches on the leaves, and although the general health of the plant is not, as a rule, materially affected, except when the spots are especially numerous and encroach on each other, forming large blotches, its general appearance is unsightly. The disease commences as minute pale spots on the upper surface of the leaf, and may be crowded or scattered, and the fact that very young leaves are frequently spotted, has been considered as strong evidence in favour of the disease being due to some parasitic organism. This, however, is not the true explanation, and a series of careful observations and experiments, described in detail elsewhere, prove conclusively

that the disease is of a non-parasitic nature, the prevention of which, by the exercise of proper precautions, is entirely under the control of the cultivator. The minute spots on the leaves, indicating the incipient stage of the disease, soon assume a pale brown colour and increase in size. As the disease progresses the spots become darker in colour, and owing to the collapse of the cells beneath the epidermis, the surface of the spot sinks below the general level of the surface of the leaf. In many instances the injury passes quite through the substance of the leaf, and shows a corresponding brown, sunken spot on the opposite side. Microscopic examination reveals the presence of a large, refringent, oleaginous-looking sphere in each cell of the browned tissue. When placed in water these spheres undergo vacuolation and constantly change their shape, after the manner of the movements shown by the vegetative or plasmodial phase of *Plasmodiophora brassicae*. These spheres correspond to the bodies discovered in diseased vine leaves, and called *Plasmodiophora vitis* by Viala. The proof that these bodies are not independent organisms, but simply globules, consisting for the most part of oils and fatty substances, is proved by the reactions shown when treated with a solution of alcannin, or with a one per cent. solution of osmic acid, when the spheres become blackened, but vacuolation is not checked so long as water is present. Tannin is also present in quantity. Mr. Watson, curator, Royal Botanic Gardens, Kew, suggested a sudden chill as the cause of the disease. Acting on this hint, a young healthy plant of *Habenaria Susannae* (R. Br.), perfectly free from 'spot,' which had been growing in a temperature ranging between 75° and 80° F., was selected for experiment. Minute particles of ice were placed at intervals on the uninjured epidermis; the plant, along with the pot in which it grew, was then placed in a sink and covered with a bell-jar, and cold water from a tap was allowed to flow over the bell-jar for twelve hours. During this period the temperature inside the bell-jar ranged between 41° and 45° F. The plant was now removed from under the bell-jar and returned to its proper house. Within twenty-four hours pale spots appeared on the leaves at the points occupied by the particles of ice, and within four days characteristic 'spot' was produced. The disease was afterwards produced, when minute drops of water were used instead of ice. Check plants submitted to the same conditions, except that the leaves were

not treated with ice or drops of water, remained free from 'spot.' The disease is produced most readily on plants that have been liberally supplied with water, and grown in a high temperature. The same kind of orchid, when in a resting condition, scantily supplied with water, and kept in a low temperature, could not be induced to 'spot.'

So far as cultivated orchids are concerned, it may be stated that spot is favoured by (1) too high a temperature; and (2) by a too liberal supply of water.

The actual cause of spot is due to watering or spraying with a falling instead of a rising temperature.

Massee, *Ann. Bot.*, 9, p. 421.

Silver-leaf.—Plum-trees suffer most, but peach, apricot, sloe, and other members of the Pruneae also show the disease. The foliage is the part affected, the upper surface of the leaf losing its normal green colour, and assuming a silvery sheen, hence the name 'silver-leaf.' This appearance is due to the presence of air-cavities under the cuticle, formed by the more or less complete separation of the cells of the epidermis, due to the splitting apart of the vertical walls. In other respects an affected leaf appears to be perfectly normal, there is no stunting, and the chlorophyll is present as usual. In some instances a single branch is attacked, which usually dies during the second season after showing the disease, the rest of the tree remaining perfectly healthy. This is more especially the case with trees grown under glass. When growing in the open the whole tree is not infrequently attacked, and then usually succumbs within two or three years, in some instances, however, lasting much longer. Trees when once attacked as a rule do not recover. The disease appears to be much more prevalent at the present day than in past times, or perhaps it is more frequently noted now.

Professor Percival claims to have proved that a fungus (*Stereum purpureum*) is the primary cause of the disease. This, however, I have not been able to confirm; I have examined hundreds of diseased trees without finding a trace of the fungus, either on the surface or in the tissues.

Another view is that the injury is due to excess of nitrogenous matter in the soil, but the disease often breaks out on a large scale in places where no such excess of nitrogenous matter exists; besides, this idea could not account for the

disease attacking a single branch of a tree. I consider the effect to be the outcome of some physiological disturbance, resulting in the production of a ferment capable of dissolving the pectic substances present in the middle lamella, and thus allowing the cells to break away from each other.

'Silver-leaf' is widely distributed. M'Indoe states: 'European varieties of plums are not so extensively grown in Auckland as in Otago, where the climate is cooler. The trees, however, suffer so much from silver-leaf disease that they are passing out of cultivation, gages being the only kinds doing well.'

M'Indoe, *Gard. Chron.*, March 21, 1909.
Percival, *Journ. Linn. Soc.*, 35, p. 390 (1901-4.).

PHANEROGAMIC PARASITES

In Britain we have but few of the higher plants that affect a parasitic habit, and some amongst these do very little injury to cultivated plants. The Broomrapes (*Orobanche*) are our most pronounced parasites, and, having no trace of chlorophyll, depend entirely on the host-plant for food from the moment of germination of the seed. The very minute seeds do not germinate unless in contact with the root of a suitable host-plant, and almost immediately after germination become attached to a root, from which they obtain the food necessary for their development. The dodders (*Cuscuta*) come next in the order of parasitic evolution. The seeds, which contain a small amount of reserve material, germinate in the ground independent of the proximity of a suitable host-plant. The radicle or tiny root enters the ground, but, as in the broomrapes, is not provided with root-hairs, and simply absorbs a certain amount of moisture from the ground, the tiny thread-like stem growing to a length of one or two inches at the expense of the reserve material in the seed. When this is exhausted the plant continues to grow for some time, drawing on the supply of food contained in the swollen radicular portion of the seedling. During this period the slender stem slowly undergoes the movements of circular nutation, feeling as it were for the stem of a host-plant. If no such plant is forthcoming the seedling dodder perishes when the supply of food contained in the lower portion of the plant is used up.

If the nutating stem touches a host-plant it at once twines round it and soon sends suckers into the tissues which henceforth supply it with food. Owing to increase in the length of the stem of the host-plant, the dodder is soon carried up away from the ground. During damp weather a seedling dodder remains alive from two to three weeks without obtaining food from a host-plant, the upper or stem portion simply feeding upon the contents of the thickened root portion. When this is consumed the seedling perishes, the entire absence of chlorophyll preventing the plant from utilising inorganic food.

The toothwort (*Lathraea squamaria*, L.) is entirely destitute of chlorophyll, and obtains a portion of its food by being parasitic on the roots of various kinds of broad-leaved trees, and another portion from minute animal organisms which are captured by its modified leaves. The entire vegetative portion of the plant remains underground, the flowering branches alone appearing above ground. When a toothwort seed germinates, slender rootlets are produced which extend through the humus until they come in contact with a slender root of a suitable host-plant, when a disc is formed, from the centre of which a slender sucker penetrates to the wood of the host-plant. When a certain number of attachments have been made and a supply of food assured, underground branches covered with thick, fleshy, colourless scale-like leaves are produced. The plant is a perennial, and the formation of underground branches continues from year to year, until a dense mass of vegetation is developed which may cover a square yard or more in the loose humus or soil. The fleshy leaves are furnished with a tortuous cavity in their interior, which communicates by a narrow channel with the exterior. This cavity is lined with absorbing glands, which extract the juices of minute animal organisms that enter the cavity. New roots producing attachment-discs are developed each year.

The mistletoe illustrates yet another phase of parasitism. Having green branches and leaves it can do a certain amount of work for itself in the way of securing and preparing food, that is, it can take in carbonic dioxide from the atmosphere, and this along with cell-sap obtained from the plant upon which it is parasitic, by the aid of its chlorophyll, it converts into starch and other requisite food. The mistletoe occurs on many different kinds of trees, and is sometimes met with on

another parasitic plant (*Loranthus europaeus*). Those trees having a soft cortex with a very tender cork-tissue are most infested, as poplars, willows, apple-trees, etc., the black poplar being an especial favourite. Certain conifers are also attacked, as the silver fir, Corsican pine, and Scots fir, but the mistletoe never appears to be quite happy when growing on conifers, and under those circumstances its seeds never contain more than one embryo, whereas when growing on broad-leaved trees, more especially on poplars, the seeds often contain two or even three embryos. The mistletoe is disseminated entirely through the agency of birds, more especially the thrush, which feeds upon the white berries, and deposits the undigested seeds along with a mucilaginous mass upon the branches of trees to which they become fixed by the hardening of the viscid substance surrounding them. When the mistletoe seed germinates its radicle comes in contact with the bark, where it forms an attachment-disc, from the centre of which a slender prolongation pierces the bark of the host-plant as a specialised kind of root. This root or sucker penetrates until it just reaches the wood of the host-plant. During the following year as the branch of the host increases in thickness, by the formation of another ring of wood, a zone of active cells at the base of the sucker commences growth and adds to the length of the sucker, which elongates outwards or away from the branch, and thus prevents the mistletoe from being engulfed in the increasing thickness of the branch upon which it is parasitic. By such an arrangement, although the sucker has not actually grown deeper into the wood, it elongates upwards each year, and is eventually surrounded by many annual rings of wood. During this period the growing zone at the base of the sucker sends off lateral strands of tissue in every direction just between the bark and the wood, and these in turn give off a series of suckers which develop in a manner similar to the primary one. By this arrangement the parasite continues to draw a constant supply of food from its host-plant.

The last batch of parasites belong to the Figwort family (*Scrophulariaceae*), and bear green leaves and resemble superficially those plants that derive the whole of their food from the air and from substances dissolved in water. These plants are the cow-wheats (*Melampyrum*), eyebrights (*Euphrasia*), bartsias (*Bartsia*), yellow-rattles (*Rhinanthus*), and louseworts (*Pedicularis*). After the germination of the seed the

plants usually continue to grow for some time before they become attached by discs formed on the rootlets to the roots of grass and other wild plants. In some species only those rootlets that come in contact with the root of a host-plant form discs, the remaining rootlets absorbing a certain amount of food from the soil like ordinary plants, although root-hairs are not in all cases present. For this reason this group of plants has been called semi-parasites.

Bartsia alpina (L.) possesses three distinct methods of obtaining food. Certain of the rootlets are furnished with root-hairs, and absorb food from the ground in the ordinary manner of green plants. Other rootlets not provided with root-hairs wander in the soil until they come in contact with the root of a host-plant, when an attachment-disc is formed, and the root is tapped for food. During the autumn small brown bulbils are formed on the roots, consisting of fleshy, overlapping scales, cavernous inside like the scales in the toothwort. These scale-leaves are in reality traps for minute animals, protozoa, etc., which serve the plant for food. During the following season aerial flowering stems originate from these bulbils.

Dr. A. Fraysse has recently been dealing with the biology of parasitic Phanerogams, and summarises his results generally as follows. Plants most readily attacked by such parasites as *Lathraea*, *Euphrasia*, etc., which attach themselves by suckers, are those containing nodules of bacteria, micorhiza, tubercles, etc. Suckers are sometimes pericyclic, sometimes endodermic in origin, and appear to represent modified roots. The invasion of the parasite usually stimulates the host to the formation of a cambium zone or a layer of cork, for the purpose of cutting off the infected area. Mucilage or gum is also often produced at the point attacked. Some green parasites obtain both mineral food and carbon compounds from their host, as *Odontites*, others, as *Euphrasia*, absorb only carbon compounds. Parasites without chlorophyll absorb the whole of their food from the host. In all instances the parasite exercises a selective power, and converts the absorbed food-materials by means of diastases into compounds that it can assimilate. Carbon appears to be mainly obtained from glucose, and a special diastase for the conversion of starch obtained from the host-plant into this substance. This glucose may be utilised at once by the parasite or again transformed into starch for future use. The suckers contain

certain substances which protect the parasite from toxins and injurious substances secreted by the host.

Fraysse, A., *New Gen. Bot.*, 19, p. 49 (1907).
Peirce, G. T., *Ann. Bot.*, 7 (1893).

The broomrapes are simple or branched plants with rather stout stems eight inches to two feet high, and covered at the lower part with sessile, scale-like leaves, destitute of chloro-

FIG. 10.—Lesser Broomrape (*Orobanche minor*, Sutt.). Entire plant, much reduced. (*Eng. Bot.*)

phyll The upper part of the stem terminates in a spike of two-lipped flowers of a dull yellow, red, or purplish colour. In one species the flowers are blue.

But little real injury to economic plants is noticed in this country. I have observed *O. minor* (= *O. Hederae* of some authors) growing most profusely on the roots of ivy in Kew Gardens for many years, without apparently causing the host-plant any inconvenience. I also had several tomato plants

attacked by *O. ramosa*, but they yielded as good a crop of fruit as neighbouring plants not attacked. *O. minor* proves injurious to clover when present in abundance.

As Bentham remarks, the species are in general difficult to characterise. Some appear to thrive only on the roots of one species, or at most two or three closely allied ones, whilst others will grow on a great variety of plants of the most remote natural affinities. But as the particular stock the plant feeds on occasions some modification in the habit of the parasite, it is in many cases a matter of great doubt whether the differences observed are owing to this circumstance or to real specific distinction. It is not therefore improbable that some of the species here adopted, although much less numerous than those usually distinguished, may on more careful observation prove to be mere varieties of each other.

Toothwort (*Lathraea squamaria*, L.) is a pale rose-coloured plant, with dingy, flesh-coloured, or slightly bluish flowers, streaked with purple or dark red. Rootstock, fleshy and creeping, covered with close-set, thick, fleshy scales. Flowering stems erect, from four to nine inches high, with a few broad, orbicular scales gradually passing into the floral bracts. Flowers in a dense spike. Flowers in early spring.

Parasitic on the roots of hazel, beech, hornbeam, elm, alder, etc., but not causing any material injury.

The dodders, of which some eighty kinds are known from different parts of the world, are all annual parasitic plants with very long, thin, thread-like, leafless stems which twine round the stem and branches of the plant they are parasitic upon. The small, wax-like flowers are produced in round clusters, and are usually white, suffused with a more or less distinct reddish flush. The stems are red or yellowish, and there is no trace of green present anywhere. The seed germinates in the ground, and the young seedling is supported for some little time by the reserve of food contained in the seed, but if it does not attach itself quite early to a suitable host-plant it perishes. If a plant that the dodder can grow upon happens to be close by, the young dodder plant on coming in contact with its host, twines round its stem, and at short intervals sends in suckers, which absorb nourishment and enable the parasite to grow along with its host. After the parasite has once gained possession of a host its root in the ground perishes and it afterwards depends entirely on its host for food. As host and parasite continue to grow the latter

extends its thread-like branches in every direction, and often completely envelopes its host in a dense, tangled mass, which suggests the idea of the plant having been bound together by a matted tangle of red thread. If the host-plant grows in clusters as in the case of furze, nettle, or clover, the parasite passes from one plant to another.

All our dodders are annuals, hence their reappearance each year depends on seed.

Clover dodder.—This is the commonest species, called *Cuscuta epithymum* (Murray), or *C. epithymum*, var. *trifolii*, by some authors. It grows commonly on thyme, furze, ling, broom, lucerne, clovers, and many other wild plants. Mr. Carruthers records an instance where a crop of clover was attacked by dodder. The clover was cut and the diseased plants left to die on the ground. No signs of dodder were observed on a crop of wheat that followed the clover, but the year following, the plough having brought the dodder seed again to the surface, it germinated after lying dormant for a year, and attacked the crop of turnips then growing in the field. The fleshy leaf-stalk and mid-rib of the leaves were chiefly attacked, but not a few of the roots were also attacked on the upper surface.

Considerable damage is sometimes done to crops of clover and lucerne by this parasite. As a rule the disease appears in scattered patches in different parts of the field, which are clearly indicated at a distance by the sickly greenish-yellow colour of the clover. If the crop is thick on the ground these patches gradually increase in size, and when conditions are favourable the greater part of the crop may become infected.

Promptitude is necessary in combating this disease. If the diseased patches are dealt with at an early stage before the dodder has scattered its seed, not only will the spread of the pest be checked, but the land will also be kept free from dodder seed, which would probably attack future crops. The most certain way of doing this is to cut off the clover close to the ground from diseased patches, taking care to remove all plants infected by the parasite. The cut clover should be removed at once and burned. If left about, put on the manure heap, given as food to cattle, a risk is incurred. If delay occurs in removing patches of diseased clover until the dodder has ripened its seed, the clover should be cut as before and allowed to lie on the ground until it will burn. It

should then be spread equally over the patch where it grew, and a little dry straw or litter added, and fired. By this means not only is the clover on the dodder destroyed, but also the seeds that have fallen to the ground.

A French scientist, M. Garrigou, recently announced that if calcium sulphide is sprinkled over dodder, the latter blackens

FIG. 11. — Dodder (*Cuscuta Gronovii*), parasitic on a species of *Aster* in Kew Gardens. Nat. size.

and withers within forty-eight hours, and during damp weather is completely destroyed in that time. A series of experiments conducted at Kew with two species of dodder proved that neither calcium sulphide nor calcium sulphate (gypsum) had any effect whatever on the dodder, although completely covered with the substance and kept damp for a week.

Dodder is introduced to land in the form of seed, mixed

with clover seed, usually of foreign origin. Dodder seed can be readily detected when mixed with clover seed by its much smaller size and different shape. Sifting with a suitable sieve will remove most of the dodder seed, but this is a tedious process for the farmer, and the purchase of clover seed should be made on the understanding that it is free from dodder seed.

Carruthers, *Journ. Roy. Hort. Soc.*
Garrigou, *Comp. Rend.* (1904); *Journ. Board. Agric.*, 130, p. 33 (1907).

Flax dodder (*Cuscuta epilinum*, Weihe) is not an indigenous wild plant, neither is it yet naturalised, but is being constantly introduced along with flax seed, and often causes serious injury to flax.

Flax seed free from dodder seed, which must be insisted upon, is the only safeguard against this pest.

Hop dodder (*Cuscuta europaea*, L.) attacks hops, nettles, vetches, and other wild plants.

Mistletoe.—The common mistletoe (*Viscum album*, L.) is too well known to require description. It is parasitic on the branches of a considerable number of different kinds of trees, and sometimes proves a serious source of injury when it attacks fruit-trees, apple and pear more especially, as that portion of a branch situated beyond the point occupied by the mistletoe rarely produces good fruit.

It is a difficult matter to protect orchard trees from attack in a district where the mistletoe is common on poplars, etc., as the seeds are conveyed by birds as previously stated. It is not sufficient to cut off the tufts of mistletoe from a branch; this method certainly retards the distribution of the parasite by means of seed, but when a tuft is simply cut off close to the branch upon which it is growing, those portions of the parasite situated under the bark in course of time give origin to other tufts. The only certain method is to remove each branch below the point where the parasite occurs. This method, although apparently drastic, is the proper one, because, as already stated, that portion of a branch situated beyond the point where a mistletoe is growing, produces inferior fruit, if any.

Lousewort.—The two British species, *Pedicularis palustris* (L.), and *P. sylvatica* (L.) are common and generally distributed. The flowers are rose-pink, leaves much divided. The former grows in bogs and marshes, and has a solitary, branched, erect stem. *P. sylvatica* grows on wet heaths and in damp pastures and thickets. Stems numerous, the central one reduced to a flowering stem, the others elongated and decumbent or prostrate.

Cow-wheat.—The four British species have slender, wiry, simple or slightly branched stems, opposite long, narrow, and entire leaves, and leaf-like floral bracts which are often coloured. For *Melampyrum pratense* (L.) the corolla is pale yellow; in *M. sylvaticum* (L.) the corolla is deep yellow; in *M. cristatum*, yellow, tipped with purple, and in *M. arvense* (L.) the corolla is rosy with a yellow throat.

The species occur in woods, copses, heaths, and pastures.

According to L. Gautier, *M. pratense* is quite specialised in its parasitism. It prefers the roots of trees, especially beech, the roots of which are well provided with mycorhiza.

Yellow rattle (*Rhinanthus crista-galli*, L.) is a very common and widely distributed plant in meadows, damp pastures, and marshes. Stem wiry, square, six to eighteen inches high, leaves opposite, long and narrow, toothed; flowers bright yellow, in the axils of opposite leaf-like bracts. Capsule orbicular, flattened, containing a few rather large, orbicular, compressed seeds which become free and rattle in the capsule when the plant is shaken, hence the popular name.

Bartsias.—Annual or perennial weeds. *Bartsia odontites* (Huds.), a branched plant with wiry stems, narrow, serrate leaves, and pink flowers in secund or one-sided spikes; is generally common in fields and waste places. *B. viscosa* (L.) is a viscid plant, corolla yellow. *B. alpina* (L.) has dull purple-blue flowers, and is more at home in the arctic region than in Britain.

Eyebright.—The only British species (*Euphrasia officinalis*, L.) is very common and generally distributed in meadows, pastures, heaths, etc. Stem wiry, much branched, four to ten inches high, leaves small, toothed, floral bracts leaf-like;

corolla bilabiate, white or tinged lilac, with purple veins, central lobe of lower lip of corolla yellow.

Bastard toad-flax (*Thesium linophyllum*, L.), a slender, prostrate weed with narrow, one-nerved leaves and minute, greenish flowers in terminal racemes. The rootstock is woody and yellow, the fibres of the root are attached to the roots of other plants growing in dry, chalky pastures, but little or no injury is done to plants of economic value.

MYCORHIZA

It has long been known that the rootlets of various plants are surrounded by a sheath consisting of fungus hyphae. Frank considered this connection between the hyphae and the root to be of a symbiotic nature, and termed the combination of the two a mycorhiza. Such rootlets present a thickened, coral-like appearance, and are often white, due to the presence of masses of oxalate of lime adhering to the hyphae. There are two principal types of mycorhiza, ectotropic and endotropic. In the ectotropic form the mycelium forms an external more or less compact sheath round the tip of the rootlet, certain branches of the mycelium penetrate between the cells of the outer layers of the cortex of the rootlet, and push haustoria into the living cells of the root. By this arrangement the host-plant is supposed to be supplied to a certain extent with water, mineral food-constituents, and organic matter, elaborated by the fungus from humus, etc. Ectotropic mycorhiza occur in every group of flowering plants, also in some cryptogams, and are best developed in plants growing in situations where humus is present; in fact the same species of plant has mycorhiza well developed when growing in soil containing humus, whereas when growing in a sandy soil, devoid of humus, mycorhiza are absent. Stahl has stated that the rate of transpiration has a considerable influence on determining the presence or absence of mycorhiza. Plants that transpire freely have feebly developed, or no mycorhiza, being enabled to obtain the required amount of mineral food due to their rapid rate of transpiration, or the comparatively rapid rate at which water containing the required salts in solution is taken up by the roots. On the other hand, where the rate of transpiration is normally slow, mycorhiza greatly assist

the plant in obtaining the required amount of water, containing salts in solution. From the above statement, it becomes intelligible why, in a particular area, some plants are furnished with mycorhiza and others are not.

Root-hairs are not present on those rootlets bearing

FIG. 12. 1, ectotropic mycorhiza of larch, nat. size; 2, mycorhiza of same, mag.; 3, section of root-tip of same, showing mycorhiza surrounding it, highly mag.; 4, portion of mycelium of same bearing amorphous masses of oxalate of lime, highly mag.; 5 and 6, endotropic mycorhiza in cells of root of an orchid, *Angraecum*, highly mag.

ectotropic mycorhiza, whereas these structures are present on roots of the same plant lacking mycorhiza.

Ectotropic mycorhiza can be readily found on species of poplars and willows, and on most members of the Cupuliferae and Coniferae.

The hyphae forming ectotropic mycorhiza belong to the

most varied types of fungi, Phycomycetes, Prenomycetes, and Basidiomycetes.

Endotropic mycorhiza are not developed externally on the rootlets, neither in the epidermal cells, but the mycelium penetrates into the cortical cells of the root, where it forms coils, which often completely envelope the nucleus. Eventually the coils of hyphae become emptied of their contents, and it is assumed that in the first instance the fungus derives nourishment from its host, which is afterwards reabsorbed by the host. Endotropic mycorhiza are abundantly developed in the roots of orchids and many other monocotyledons, also according to Frank, in members of the Ericaceae, Epacridaceae, Empetraceae, and other plants living in humus in moors, heaths, woods, etc.

Root-hairs are not suppressed by the presence of endotropic mycorhiza.

There is considerable diversity of opinion, even amongst those who have paid most attention to the subject of mycorhiza, as to whether plants do in reality benefit by their presence.

Frank, *Ber. d. deutsch. Bot. Ges.* (1885).
MacDougal, *Ann. Bot.*, 13, p. 3 (1889).
Massee, *A Text-book of Fungi*, p. 142 (1906).
Stahl, *Pringsh. Jahrb.*, 34, p. 539 (1900).
Ward, *Ann. Bot.*, 13, p. 549 (1889).
Woronin, *Ber. d. deutsch. Bot. Ges.*, 3, p. 205 (1855).

FUNGI

It is not possible in this place to give a detailed account of the peculiarities and mode of life of the fungi; for such information, books devoted to the subject must be consulted. The horticulturist as a rule equally condemns all fungi, and considers that only injury can result from their presence. This however is not so; myriads of noxious insects are destroyed by fungi, the most familiar example perhaps to the ordinary non-observer being the common house-fly, fixed to a window-pane, and surrounded by a halo of fungus mycelium. Caterpillars, many of large size, are preyed upon and eventually killed by fungi in every part of the world. The caterpillar is infected with fungus spores while still alive, but is

finally killed by the mycelium of the fungus, which converts its body into a mummified mass of spawn, which at a later stage produces a club-shaped spore-bearing structure, the

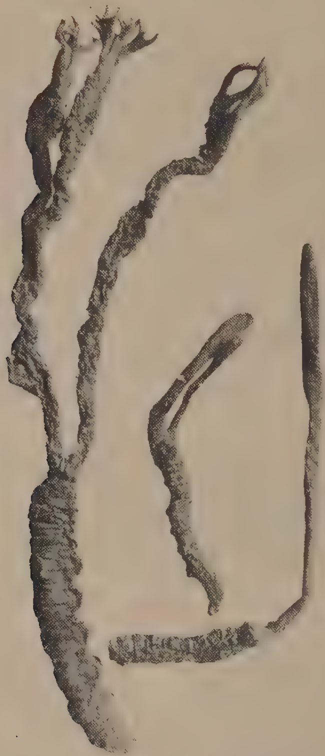

FIG. 13.—Species of *Cordyceps*, parasitic on caterpillars which they have killed. Reduced.

spores from which in turn infect other caterpillars. Certain kinds of fungi confine their attentions to particular kinds of insects, and of late years considerable progress has been

made in the way of favouring the presence of those fungi that attack insects especially injurious to certain cultivated plants and trees. This idea is as yet in its infancy, but it is expected that good results will follow a more extended knowledge of the subject.

Again, fungi must be considered as the scavengers of the Vegetable Kingdom. All dead and dying vegetable matter is seized upon by fungi, and soon reduced to a condition in which it can be again utilised as food by plants; whereas, without the intervention of fungi, such material would remain for ages before it decayed. Finally many fungi serve as food for man, animals, more especially rodents, insects, etc.

The most salient feature characterising fungi is their mode of obtaining food, which differs so essentially from that of the plants cultivated by the farmer and gardener. No fungus obtains any portion of its food directly from the air or from the soil, but depends entirely on the material composing the bodies of animals or plants, more especially the latter. When fungi obtain their food from living animals or plants, they are called *parasites*, whereas when they derive their food from dead plant substances, they are termed *saprophytes*. Many fungi are strictly parasites or saprophytes, others are capable of changing from one condition to the other, depending on circumstances.

Another peculiarity of many fungi is the totally different appearance assumed during different periods of their life-cycle. This is most marked in the group known as 'rusts' and 'mildews' of cereals and other plants. Not only does the fungus differ in general appearance and structure during different phases or stages of its development, but in many cases the different stages in the development of the fungus grow on different kinds of host-plants. This condition of things is known as *heteroecism*, and is illustrated in rust or mildew of wheat, where one stage of the fungus flourishes on the leaves of the common barberry, while two other stages of the same fungus grow on the leaves of the wheat plant.

The majority of fungus parasites, and other kinds also, in addition to the higher form of fruit, have one or more secondary or conidial conditions, which reproduce conidia or summer-spores in rapid succession during the entire period that the host-plant—*i.e.* the plant on which the fungus is parasitic—is in vigorous growth, and it is in almost every

instance infection effected by the conidial form that causes an epidemic, or widespread disease. The higher or ascigerous form, on the other hand, usually produces what are termed winter-spores, which remain in a period of rest during the winter, and infect the host-plant the following season.

There are three principal groups of fungi, Phycomycetes, Ascomycetes, and Basidiomycetes, along with some connecting groups that cannot be considered here.

The Phycomycetes may be considered as the pioneers of fungi as a definite group of plants that evolved from the Algae, and retain many features characteristic of the last named family of plants. Sexual reproduction is present in many of the members, and the reproductive bodies in many instances consist of zoospores or motile bodies, that require the presence of water to enable them to reach their destination and inoculate the host. Most of the species are minute, and when visible to the naked eye come under the category of moulds. As examples may be mentioned, *Phytophthora infestans*, the cause of the well-known potato disease, and *Pythium de baryanum*, the cause of 'damping off' in seedlings. The resting-spores are the direct result of sexual action. Conidial forms are numerous.

The Ascomycetes are characterised by having the spores produced, usually in a definite number, in specialised cells or asci. This group consists of four families, Perisporiaceae, Pyrenomycetaceae, Discomycetaceae, and Hysteriaceae. In the Perisporiaceae the asci are contained in a special, minute, more or less globose structure or perithecium, entirely devoid of an opening, hence the perithecium has to decay before the spores can escape. These fungi are popularly known as mildews, of which the mildew of the hop and the rose are familiar examples. The mildew is the conidial stage of the fungus. Black mildews are common in tropical countries. In the Pyrenomycetaceae the perithecia have a distinct opening or mouth, through which the spores escape at maturity. Many species are very minute, forming black dots on stems, wood, and leaves. Others, as the candle-snuff fungus, are large. Many species are destructive parasites. Conidial forms numerous. In the Discomycetaceae the fungus fruit takes the form of a cup or a saucer, sometimes seated flat on the host, at others supported on a more or less elongated stalk. Many species are brilliantly coloured, and the size varies from that of a mere point to two or three inches in

diameter. Larch canker and brown rot of fruit are caused by fungi belonging to this group. The Hysteriaceae are a comparatively small group connecting the Pyrenomycetaceae with the Discomycetaceae, agreeing with the former in the minute, usually black fruit, which instead of being a spherical perithe-

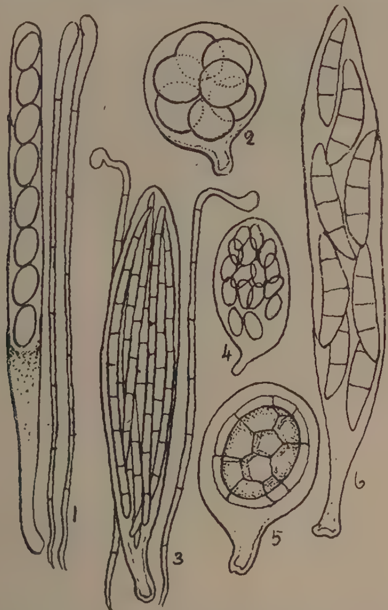

FIG. 14.—Typical forms of asci. 1, ascus of *Peziza cerea*, containing eight spores, also two paraphyses; 2, ascus of *Sphaerosoma Leveillei*; 3, *Geoglossum Peckianum*, the long needle-shaped spores are in a bundle, paraphyses curved at the tip; 4, *Ryparobius sexdecemsporus*, sixteen spores in an ascus; 5, *Tuber excavatum*, ascus with one large spore; 6, *Zignoella corticola*. All figs. highly mag.

cium, is elongated or star-shaped, and instead of a minute mouth or pore, splits along its whole length to admit of the escape of the pores.

In the Basidiomycetes the pores are not produced in asci, but are borne at the tips of specialised cells called basidia.

As a rule a basidium bears four spores at its apex. There are two important groups, Agaricaceae and Gasteromycetaceae. In the former, represented by mushrooms and toadstools, the basidia are borne on the gills, whereas in the Gasteromycetaceae, including puffballs, stinkhorn, etc., the spore-bearing portion is at first concealed in a membrane or volva.

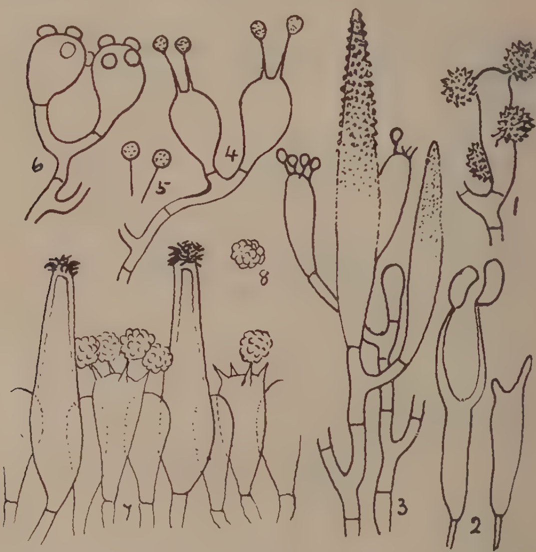

FIG. 15.—Typical forms of basidia, with spores in the Basidiomycetes. 1, *Tulostoma mammosum*; 2, *Dacromyces deliquescens*; 3, basidia with spores, and cystidia of *Peniophora inconspicua*; 4, bisporous basidia of *Lycoperdon echinatum*; 5, two spores of same showing persistent sterigmata; 6, *Scleroderma vulgare*; 7, portion of hymenium of a typical agaric, *Inocybe asterospera*, with basidia, bearing spores, cystidia, or sterile basidia, and elongated cystidia. All highly mag.

There is much difference of opinion as to the exact position, in the sequence of evolution, of the two important families, Ustilaginaceae—smuts and bunts of cereals, etc.—and the Uredinaceae—rusts and mildews of cereals and other plants. In the latter group heteroecism is rampant. The members of both groups are almost without exception

destructive parasites. Finally, there is the provisional group called Deuteromycetes or 'Fungi imperfecti,' an enormous assemblage of forms that are considered as representing

FIG. 16.—*Lentinus cyathus*, an agaric springing from a sclerotium; the latter shown in section. One-sixth nat. size.

conidial phases of the groups previously enumerated. Large numbers of these are amongst the most destructive of parasites.

Although spores, in the wider sense of the term, are the most general forms of reproduction, conidia or summer-

spores enable the fungus to extend rapidly from one host-plant to another, and thus extend its area of distribution; winter or resting-spores, that tide the fungus over the winter and set up a new infection on the host-plant the following season. In addition to these there are various modes of vegetable reproduction which are quite as effective, and more difficult to combat than true spores, in starting a disease, as they are usually formed in the diseased parts of plants, and find their way back to the land, or are produced at first-hand by mycelium present in the soil. In many instances such reproductive bodies consist of dense masses of mycelium, usually black externally, and varying in size in different kinds of fungi, from a pin's head to that of a cricket ball. These sclerotia remain for some time in a resting condition and then produce either spore-bearing bodies or give off mycelium, capable of infecting a host-plant.

A general account of the fungi will be found in the following books:

Massee, Geo., *A Text-Book of Fungi.* Duckworth and Co., London (1906).

Tavel, Dr. F. von, *Vergleichende Morphologie der Pilze.* Fischer, Jena (1892).

BIOLOGIC FORMS OF FUNGI

In the case of many parasitic fungi, certain members of a given species have become so modified and specialised in their parasitism, that they can only infect a given species of host-plant, or, at most, a few closely allied species. Such are termed biologic forms, on account of their speciality in this direction being of a purely physiological nature, depending on possessing distinct and sharply-defined powers of infection. No morphological differences are presented by biologic forms belonging to the same species. As an example, the morphological species called *Erysiphe graminis* (D. C.) is parasitic upon barley, oats, wheat, and many wild grasses. Culture experiments have proved, however, that the particular form parasitic upon any one of the plants enumerated above cannot infect any of the other plants. Thus the form parasitic upon wheat cannot infect rye, etc. Salmon has shown that this specialised and restricted power

of infection is possessed both by the conidial form of *Erysiphe graminis*, and the spores of its ascigerous condition.

Up to the present, biologic forms have been mostly noted in fungi belonging to the Erysiphaceae or powdery mildews, but judging from the numerous known cases, where the same species of fungus belonging to other orders is known to be parasitic upon only one kind of host-plant, it is highly probable that in the near future the presence of biologic forms of species will be shown to exist in all orders of fungi including parasitic species.

From an economic standpoint, it is perhaps difficult to decide as to whether the evolution of biologic species is a blessing or a curse. If half a dozen kinds of wild grasses growing round the borders of a wheat field are infected with *Erysiphe graminis*, it is reassuring to know that the spores diffused from one or all of these grasses cannot infect a wheat plant. On the other hand, if a single stray wheat plant, infected with the fungus, happens to be growing near the wheat field, infection occurs, and spreads like wild-fire over the field, the rate of infection assuming the proportion of an epidemic, on account of the special infective power of the biologic form over one kind of host-plant only.

Marchal, *Comp. Rend.*, 135, p. 210 (1902); 136, p. 1280 (1903).
Neger, *Flora*, 90, p. 221 (1902).
Salmon, in Massee's *Text-Book of Fungi*, p. 146 (1906).
Salmon, *Phil. Trans.*, 197, p. 107 (1904).

PHYCOMYCETES

The present order includes the most primitive types of fungi, many of which retain the aquatic habit of the algae from which they evolved, as the Saprolegniaceae. Other groups, as the Peronosporaceae, which have in part become modified and adapted to an aerial mode of life, still have their reproductive organs produced in the form of zoospores or motile bodies, which require the presence of water to enable them to move from one place to another, hence the infection of new hosts depends on the presence of water. In other members of the group the conidia are

dispersed by wind, and thus have become independent of water as a means of spore dispersion.

All the species are minute, some amongst parasitic forms can only be seen when highly magnified, as *Pythium de baryanum*, causing 'damping off' in seedlings. In some genera no trace of mycelium is present during any stage of development, whereas in the white mildews (*Peronospora*, *Phytophthora*, etc.) there is a copious development of mycelium present in the tissues of the host, and also a forest of conidiophores on the surface.

A sexual mode of reproduction is more frequently present in the Phycomycetes than in any other group of fungi.

Massee, Geo., *British Fungi, Phycomycetes and Ustilagineae*. L. Reeve and Co., London.

PROTOMYCES (Unger)

Parasitic in the subepidermal tissues of plants, generally forming coloured, swollen patches, resting-spores numerous, terminal or intercalary, produced on mycelium which soon disappears, wall thick, usually consisting of two layers, hyaline or coloured.

The dense groups of resting-spores often form hard, modular swellings on the host. Conidia are unknown. On germination the thin endospore, crowded with minute cylindrical, motionless spores, protrudes intact through a rupture in the wall of the resting-spore. The liberated spores conjugate in pairs, and afterwards produce a germ-tube which enters the host-plant and develops into a new parasite resembling the genus *Synchytrium* in habit, but distinguished by the presence of mycelium.

The species cannot be considered as destructive parasites.

Protomyces macrosporus — Unger, forms small, often elongated warts on the stem and leaf-stalks of various kinds of umbelliferous plants, more especially goutweed—*Aegopodium podograria*, resting-spores, subglobose or elliptical, wall-smooth, yellowish-brown, 30-38 μ diam. spores, cylindrical, colourless, $2\text{-}2{\cdot}5 \times 1\ \mu$.

Protomyces rhizobius (Trail) forms small nodules on the roots of *Poa annua*.

Resting-spores in groups of from 2-8, mixed with

delicate mycelium, in the cortex of the root, 30-33 μ diam., wall 10-12 μ thick.

Protomyces pachydermus (Thum.) forms rather prominent brown warts on leaves and leaf-stalks of carrot and dandelion.

Resting-spores subglobose, wall pale brown, 14-24 μ diam.

Protomyces menianthis (De Bary) forms small clusters of warts seated on red, then brown, patches, on leaves of *Menianthes trifoliata* and *Comorum palustre.*

Resting-spores subglobose or angular, brown, 20-40 μ diam.

Protomyces ari (Cooke) forms irregular bleached patches on leaves and leaf-stalks of *Arum maculatum*; the warts are not prominent.

Resting-spores subglobose, brown, 14-20 μ diam.

Protomyces purpureo-tingens (Mass.) forms elongated or broadly effused patches of a red or purple colour on the cotyledons and young leaves of the sunflower and garden specimens of *Smilacina.*

Resting-spores solitary, rarely two, subglobose, 25-28 μ brown wall, minutely warted.

Protomyces concomitans (Berk.). This pest was described by Berkeley in *Gard. Chron.*, 1882, p. 397, as destructive to cultivated orchids, appearing on the leaves under the form of somewhat pale, moist spots.

Resting-spores globose, pale amber.

I have no knowledge of this parasite, which so far as I am aware has not been observed since its discovery by Berkeley.

OLPIDIUM (A. Braun)

Vegetative condition passive naked protoplasm, the product of one spore. This enters a cell of the host and becomes surrounded by a wall, the contents of which become resolved into 1-ciliate zoospores, which escape through a long beak reaching beyond the host-cell. In other instances the cell becomes thick-walled and forms a resting-spore, which in turn gives origin to zoospores. No sexual reproduction.

The total absence of mycelium and the presence of a long beak to the cell, through which the zoospores escape, are the chief features of that genus.

Seedling cabbage disease (*Olpidium brassicae*, Dang.) often causes devastation in beds of seedling cabbages; the injury comes from the gardener's point of view under the category of 'damping off.' The tender cells of the young stem are attacked by the fungus, soon the plant droops, falls down, and dies.

Sporangia, solitary or several in each cell of the host, the long slender tube from which the zoospores escape often passes through a layer of four or five cells to reach the surface of the host-plant. Zoospores 1-ciliate, globose. Resting-spores tinged yellow, warted.

FIG. 17.—*Olpidium brassicae*. 1, zoosporangia in cells of cabbage leaf; 2, zoospores; 3, resting-spores. All highly mag.

From a scientific standpoint this fungus should be recognised from the similar effects produced by *Pythium de baryanum* (Hesse), although the practical preventive measures apply equally to both pests.

Plenty of sunlight, and absence of excess of moisture in soil and air are the only practical remedies. Where the disease has shown itself is an indication that the locality is too damp.

Woronin, *Pringsh. Jahrb.* (1878), p. 557.

Olpidium lemnae (Schröt.). This parasite is met with in the epidermal cells of the duckweed (*Lemna minor*).

Zoosporangia globose, with a long beak, 18-20 μ diam., resting-spores globose, almost colourless, 12-20 μ diam.

CHYTRIDIUM (A. Braun)

Zoosporangia sessile in cells of the host-plant, the base forming a root-like continuation cut off from the sporangium by a septum, zoospores globose, 1-ciliate. Hard-walled resting-spores are formed in the tissues of the host.

Chytridiosis of the vine.—A somewhat startling account is given by Prunet, respecting the occurrence of a species of *Chytridium* which he has found as a parasite on the vine. The fungus is stated to be present on all the organs of the plant, and also in all the tissues. It is frequently so abundant that each of the living cells included in a section contains one sporangium, very frequently two, rarely three or four. This is especially true of the cells of the pith, especially when their presence is made clear by staining.

According to the special organ, or the special kind of tissue, the *Chytridium* produces very different effects, is the real cause of a number of ill-defined diseases, as 'd'anthracnose ponctuée, anthracnose déformante, gommose bacillaire, gélivure, roucet, brunissure, brunissure-rougeole, maladie pectique, maladie du coup de pouce.' It is also said to be the cause of certain kinds of chlorisis, and of various ailments of the vegetative and reproductive organs, which the author promises to enumerate in the future. It has also been proved to be the cause of the disease called *mal nero* attacking vines in Italy.

The fungus proved to be a new species, and received the name of *Chytridium viticolum* (Prunet).

Zoosporangia ovoid or fusiform, terminal or intercalary, $10\text{-}40 \times 3\text{-}15\ \mu$. Zoospores globose, with one delicate cilium, $1{\cdot}5\text{-}2{\cdot}5\ \mu$ diam.

Some of these sporangia are produced in pairs, of which one is smaller than the other, and shrinks as 'if its contents had passed into the larger one, suggesting fertilisation.' The zoosporangia constantly give off fine filaments of mycelium, which pass into adjoining cells and form zoosporangia, which again repeat the same process. The zoospores soon germinate and give off germ-tubes, which spread in the tissue. Cysts or thick-walled resting spores are formed, which after a period of rest give origin to zoospores.

Up to the present, so far as I am aware, this dreadful pest

has not been recorded in this country. May it never come! There is just the chance, however, as the author has met with it in Algeria, Tunis, and in five different districts in France. It was also found on a wild vine from the banks of the Mississippi.

Prunet, M. A., *Comp. Rend.*, 119, pp. 572, 808, and 1233 (1894).

Chlorochytrium graminis (Büsgen) attacks the root and leaves of different kinds of pasture and lawn grasses; the disease spreads from a centre, killing off the herbage and leaving naked patches. Species of *Poa*, *Panicum*, and *Avena* are susceptible to the disease, but I failed to infect seedlings of *Bromus* and *Hordeum*. If the yellow, fading, or dead basal leaves are examined, the tissues, more especially along the edges of the leaf, are seen to be crowded with the resting-spores of the fungus.

Resting-spores elliptic-oblong, wall smooth, almost colourless, rather thin, $35\text{-}45 \times 24\text{-}32\ \mu$.

PYROCTONUM (Prunet)

Mycelium broadly effused in the matrix, consisting of very delicate filaments. Zoosporangia formed from swellings of the mycelium. Zoospores globose, 1-ciliate, later becoming clothed with a wall, about $3\ \mu$ diam. Secondary zoosporangia are formed within the old primary empty ones. When badly nourished the zoosporangia become changed into cysts or resting-sporangia, furnished with a thick, brown wall.

Dwarfing of wheat.—A. Prunet has described a serious disease of wheat caused by *Pyroctonum sphaericum* (Prunet) one of the Chytridiaceae. The symptoms are a general arrest of growth, followed by a progressive yellowing and shrivelling of the leaves, but usually the entire plant is not killed for some considerable time. The patches of stunted, shrivelled corn in a field extend in area under favourable climatic conditions, and may assume considerable dimensions. All parts of the plant, root, stem, leaves, and flowers are eventually attacked, the presence of the parasite in the ovule causing the abortion of the grain.

Mycelium branched, intracellular, broadly effused, consisting of exceedingly slender hyphae, zoosporangia ovoid or

piriform, terminal or intercalary, 15-50 μ diam. Zoospores angular, then globose, 1-ciliate, becoming clothed with a membrane, about 3 μ diam.

Prunet, *Comp. Rend.*, 119, p. 108 (1894).

UROPHLYCTIS (Schröt.)

Zoosporangia sessile on the living host, with filamentous mycelium penetrating the tissues. Thick-walled resting-spores resulting from the conjugation of two cells are formed in the tissues of the host.

Crown-gall of lucerne.—This is produced by *Urophlyctis alfalfae* (Magn.), and was first observed in this country by Mr.

Fig. 18.—*Urophlyctis alfalfae.* Nodules on root and collar of lucerne plant, formed by the fungus. (After Salmon.)

Salmon, who gives the following account of the epidemic: 'The following inoculation experiments were carried out to demonstrate that the resting-spores, on being set free from the

"gall" and dispersed in the soil, are able at once to produce the "crown-gall" of lucerne, and also to ascertain whether the fungus can attack other plants, such as mangold, potato, etc.'

During the winter of 1905-6 a number of badly diseased lucerne plants, covered with galls, were obtained from a farm near Herne Bay. These 'galls' were kept dry in the laboratory through the winter, and a number were then taken from time to time and first soaked in water, and then ground up in water with a pestle and mortar. A drop of this water, on being placed under the microscope, was seen to contain many hundreds of the resting-spores of the fungus.

Six well-grown and healthy plants of lucerne, beet, mangold, and potato, in 9½ inch pots, were richly inoculated with the spore—containing water, the water being poured not only over the crown of the roots and the surface of the pot, but also into a number of vertical 'borings' which reached to half the depth of the pot. Six 'control' pots of each kind of plant were kept side by side with the inoculated ones. All the pots were sunk in the earth in the experimental ground. Later in the season the twenty-four inoculated pots were again similarly inoculated. The dates of the two inoculations were chosen so that, in the case of each of the four plants, the first inoculation was made just as the first shoots appeared above ground, and the second when the shoots were full grown for the season. In November all the plants were examined. On five out of the six inoculated lucerne plants[1] a number of 'galls' had been produced. In two cases the attack of the fungus had been so virulent that the lucerne plant was actually killed. No formation of 'galls' occurred on the 'control' lucerne plants, nor on any of the inoculated or 'control' plants of mangold, beet, or potato.

The present disease has not been observed in England previous to the Herne Bay case in 1906, and no fresh case has since come under my notice. It will be well, however, for farmers to keep a careful look-out for this new disease, since in several countries on the continent, and also in South America, it has proved to be very destructive to cultivated lucerne. So far as the present investigations show, it is safe to grow beet, mangold, or potatoes after lucerne which has suffered from this disease.

This is one of the numerous instances where the only safe

[1] These were two-year-old plants.

remedy against the infection of future crops is one which is scarcely practicable, that of removing every infected root from the soil and burning them.

Even if this were done there is the risk of fragments of diseased portions remaining. As the disease appears to be confined to leguminous plants, no such crops should be grown on land bearing a diseased crop for some years.

Salmon, *South-Eastern Agric. Coll.*, *Wye*. July (1907).

Carum leaf-galls.—Magnus has described galls found on *Carum carvi*, *C. persicum*, and *Pimpinella magna* by *Urophlyctis Kriegeriana* (P. Magnus). The galls are small and pearl-like and occur on the surface of the leaves, stem, and floral parts. Adjoining cells often fuse more or less completely and form hyaline punctate crusts, especially on the stem. Each gall has a slight depression at its apex, which leads into a very large cell in the middle of the gall. The fungus is confined to this cavity. The formation of a gall is caused by a germ of the parasite entering an epidermal cell, which in consequence swells considerably and causes repeated division of neighbouring cells, forming a thick wall round the central enlarged cell, and leaving an opening at the apex. The membrane at the apex of the gall is traversed by a filament of mycelium which dilates into a vesicle, from which other hyphae originate. This process is repeated until a quantity of hyphae are produced, which eventually produce conjugating cells. Male and female conjugating cells arise respectively from distinct sets of hyphae. At first the conjugating cells are of nearly equal size, soon, however, some increase considerably in size, while others remain small—the male cells—and the contents of a smaller cell pass through a connecting tube into a larger cell. The female cell, after conjugation, continues to enlarge, and forms a thick, dark brown wall. On the side where conjugation takes place, the cell remains flat and somewhat depressed at the centre. The presence of zoosporangia has not been observed in this species.

Magnus, P., *Sitzungsb. Gesell. Natur-Freunde*, *Berlin* (1888), p. 100.

Magnus, P., *Ann. Bot.*, 11, p. 87 (1897).

Beetroot tumour.—This is caused by *Urophlyctis leproides*

(P. Magnus) = *Oedomyces leproides* (Trabut). It was first observed attacking beetroot, *Beta vulgaris*, var. *rapacea*, in the grounds of the School of Agriculture, Rouiba, near Algiers. A portion of a beetroot bearing this disease was once sent for investigation to the Scientific Committee of the Royal

FIG. 19.—*Urophlyctis leproides*. 1, diseased beetroot, reduced. 2, spore, highly mag.

Horticultual Society; this is the only specimen of the disease I have seen in England, in fact it could not be ascertained with certainty where the particular beetroot in question was grown, and it may possibly have been of foreign origin.

The upper portion of the root is the part attacked, large

nodulose outgrowths, sometimes the size of a walnut, and attached by a narrow base are formed, consisting of modified rootlets, or in some instances probably leaves; the thick, fleshy, primary root is not usually attacked. These tumours contain numerous cavities filled with the resting-spores of the fungus. The original cyst, instead of remaining simple and rounded as in *U. Kriegeriana*, sends out irregular outgrowths, which react on the surrounding parenchyma, causing rapid division of cells, and consequent increase in size of the tumour. The extensions of the original cyst in turn become inflated and occupied by the fungus. This process is repeated until eventually a large tumour is the result, its tissues enclosing numerous cysts or spore-bearing cells, originating from each other, and connected by necks or narrow passages. The fungus is confined to the cysts, not entering the parenchyma. The male conjugating cells are produced on different hyphae to those giving origin to the female cells. At maturity receiving cells become clothed with a thick, brown wall having a depression on one side. These cells measure $45\text{-}50 \times 30$ μ. Swarm-sporangia have not been observed. Saccardo founded the genus *Oedomyces* on this species, and referred it to the Ustilaginaceae. In the generic character Saccardo states that the spore is terminal, and immediately beneath it is a vesicular swelling. The true explanation of this is, the female cells become free from their supporting hypha before conjugation, and the 'vesicular swelling' is in reality the small male cell joined to the female cell by the conjugating tube. This condition of things was figured by Trabut and copied by myself.

The only prevention of an epidemic is removing and burning diseased plants before the resting-spores are liberated in the soil.

Magnus, *Ann. Bot.*, 11, p. 87 (1897).
Massee, *Text-book of Plant Diseases*, p. 225 (1899).
Saccardo and Mattirolo, *Malpighia*, 10 (1895).
Trabut, *Rev. Gén. de Bot.*, 6, p. 409 (1894).

Urophlyctis Rübsaameni (Magnus) forms tuberous excrescences 2-3 cm. long, on roots of *Rumex scutatus* in Germany. Spores smooth, brown, slightly concave on one side, 40-45 μ diam.

Urophlyctis trifolii, Magnus (=*Synchytrium trifolii*, Pass.)

forms subglobose, glassy-looking pustules up to 1 mm. broad, on the leaves and petioles of *Trifolium montanum*, *T. pratense*, and *T. repens* in Italy and Germany. Spores subglobose, smooth, wall double, outer thin, brown, endospore thick, 40-58 μ diam.

SYNCHYTRIUM (De Bary and Wor.)

Zoospores penetrate the tissue of the host and form a plasmodium which becomes surrounded by a thick membrane and forms a resting-spore, which on germination liberates its contents as zoospores, or as a single mass which divides directly into zoospores, or into a group of thin-walled sporangia containing zoospores.

No mycelium present at any stage. Parasitic in the tissues of plants, more especially in the epidermal cells.

Black scab of potatoes.—This disease is caused by *Synchytrium solani* (Massee.) It is also known locally as 'Wart disease,' 'Cauliflower disease,' and 'Canker fungus.'

In a typical example of black scab the tuber bears one or generally several prominent rugged outgrowths or warts, which vary in size from a marble to that of a walnut. These warts are coloured like the potato at first, but eventually become almost black, hence the name black scab. Less frequently the lower leaves are also infected and converted into fleshy, shapeless masses. The tuber itself is never infected, but only the sprouts, which are attacked when quite young. The act of infection by the parasite causes hypertrophy or much increased local growth of the infected sprout. Continued infection from outside stimulates the sprout, which gradually spreads to a greater or less extent over the surface of the tuber, until a tumour-like mass is formed. When all the sprouts are attacked, the entire surface of the tuber is often covered with excrescences. Infection is always effected by the zoospores of the fungus present in the soil, and only very young superficial cells not protected by periderm can be entered. When a cell is once infected or entered by the parasite it is incapable of further division, but those superficial cells that escape infection rapidly divide and form a mass of tissue that soon overlaps the original surface cells. This process is frequently repeated,

so that eventually, cells that formed the peripheral or outside row are deeply buried in the tumour, and resting-spores are

FIG. 20.—*Synchytrium solani*; Black scab of potato.

consequently met with buried deeply in the flesh of the tumour. It will be observed, however, in examining a section of a wart or tumour, that the oldest and most perfectly

matured resting-spores of the fungus are deepest down in the tissue, and that these become smaller and younger as the periphery is approached, and that in the outermost layer of cells for the time being the parasite is in a kind of plasmodial condition, very small, and entirely destitute of a thick, chitinous wall.

The disease is said to have been known to potato-growers in the Liverpool district for some sixteen years past. Its presence was, however, only made generally known in 1901, when Professor Potter and myself simultaneously and unknown to each other sent an account of the disease to the Journal of the Board of Agriculture. Professor Potter stated that the organism causing the disease was *Chrysophlyctis endobiotica* (Schilberszky); I, on the other hand, considered the fungus to be *Endomyces leproides* (Trabut). It is now evident that both were mistaken in our identification. On the appearance of such discrepancy as to names, I sent a typical specimen of the disease to Dr. Schilberszky, asking him if it was his *Chrysophlyctis endobiotica*. His reply was that it was not his species, and that it was unknown to him. This letter from Dr. Schilberszky was not kept, hence when the subsequent controversy as to names was resumed, the information I have now given could not be used officially, lacking the necessary evidence. A very remarkable feature in connection with the parasite under consideration is the entire absence of the formation of periderm as a protection against further encroachment, whereas in other potato diseases periderm is produced on the least encroachment of any outsider. This fact, coupled with the statement in the very brief preliminary notice given by Schilberszky of his potato disease, that crater-like structures are formed, in addition to the formation of periderm, does not tally with what is met with in black wart disease. For my own mistake I can offer no satisfactory explanation.

For several years persistent attempts have been made to germinate the resting-spores, but without success, until last year when the announcement was made, almost simultaneously by Professor Johnson of Dublin, Professor Potter of Newcastle, and myself, that the resting-spores had been induced to germinate. The two first-named observers recorded the fact in very brief terms, but agreed that uniciliate zoospores were liberated. In my own case the resting-spores were nine months old when they germinated. A crack appeared in the brown chitinous wall, and the broadly piriform, 1-

ciliate zoospores, 3-4 μ in diameter in some instances, escaped directly into the water of the hanging-drop, whereas in other instances, the inner hyaline wall of the resting-

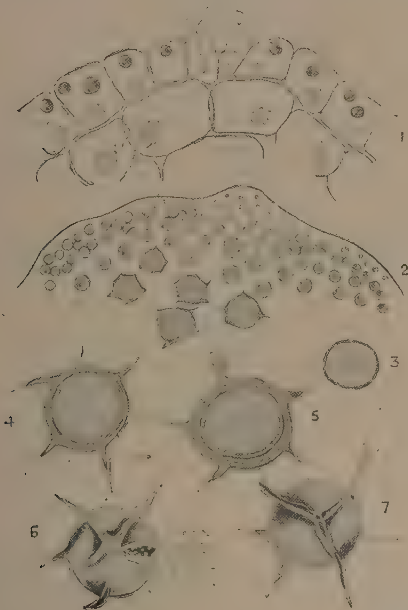

FIG. 21.—*Synchytrium solani*. 1, section through portion of a young potato sprout, showing many of the peripheral cells infected by the zoospores of the fungus. The central cell that is dividing has escaped infection; 2, section through a portion of a scab, showing mature resting-spores deep down in the tissue and the youngest at the periphery; 3, a young resting-spore not yet enclosed in a thick wall; 4, 5, and 7, mature resting-spores; 6, a resting-spore germinating, 1-ciliate zoospores escaping. All highly mag.

spore, containing the zoospores, was extruded, the zoospores eventually escaping into the water. The epidermal cells are infected by the zoospore, which at first forms a naked mass of protoplasm that gradually increases in size, then becomes invested with a thin, colourless wall, upon which is eventually laid down a thick, brown, smooth, stratified, chitinous wall.

As a rule only one resting-spore is present in a cell of the host-plant, 40-70 μ diam.

For the reasons given above, I consider the fungus causing black scab in potatoes to be a typical species of *Synchytrium*, and quite distinct from the fungus indicated by Schilberszky.

The disease is now unfortunately fairly common in this country, but its presence has only been recorded twice on the continent—in Germany. Curiously enough no record exists of its occurrence in Hungary, the country from which Dr. Schilberszky obtained his specimen of *Chlorophlyctis endobiotica*.

The only methods that can be suggested for checking the spread of the disease are of a preventive nature, and as these are unfortunately mostly outside the range of what may be expected of the potato-grower, or, for the matter of that, any one else, the field is open for the stump-orator, whose energies are expended in denouncing the powers that be for not promptly suppressing all trace of the disease from the British Empire. Difficulty No. 1 consists in the fact that a potato used for 'seed' may be so slightly infected that the disease would not attract the attention even of an expert. If such a potato is used for 'seed' a diseased crop will probably result, at all events the land in which the crop grew will be infected. Difficulty No. 2 turns on the fact that when land is once infected it remains in a condition capable of imparting the disease to potatoes after a period of five years, as proved by careful experiments conducted at Kew. This infection is brought about by the liberation of the resting-spores of the fungus into the soil. When a potato becomes diseased the presence of the fungus in the tissues enables other fungi and bacteria to gain admission, and the tuber often rots and decays under the combined influence of these various organisms before the time for lifting the crop arrives. No amount of legislation can prevent the rotting of such potatoes, and the consequent liberation of resting-spores in the soil. It is an insult to any potato-grower to caution him against using for 'seed' potatoes obviously attacked by black scab; on the other hand, if he uses 'seed' so slightly attacked that he cannot see the disease, he is not responsible for the result. The only suggestion that can be offered is that of procuring 'seed' from a district where the disease has not been notified. So far as is known, the disease is confined to the potato, consequently when land

is known to be infected, by having produced a diseased crop, do not attempt to grow a crop of potatoes again for at least six years, unless very stringent measures are taken to destroy the organisms present in the soil. The land must be fallowed and dressed with gas-lime, at the rate of from four to five tons per acre. Slightly diseased potatoes should not be given to animals raw, but should be always boiled first.

Journ. Bd. Agric., Leaflet No. 105.
Massee, *Journ. Bd. Agric.*, 9, p. 307 (1902).
Percival, *Journ. Bd. Agric.*, 9, p. 320 (1902).
Schilberszky, *Ber. d. deutsch. Bot. Gesell.*, 14 (1896).

FIG. 22.—*Rhizopus nigricans*. 1. portion of fungus; 2, zygospore; 3, spores; 4, *Synchytrium taraxici*; resting-spore in epidermal cell; 5, resting-spore liberating a mass of sporangia; 6, a sporangium liberating zoospores. All highly mag.

Synchytrium Niessii (Bubák) forms warts on the leaves of *Gagea* and *Ornithogalum umbellatum*. The warts are at first dirty white, bounded by a dark brown line. Resting-spores globose, single or 2-10, sometimes up to 20 in inflated or spindle-shaped epidermal cells.

Bubák, F., *Sep. Österr. Bot. Zeitschr.*, No. 7, Ser. 2 (1898).

PYTHIUM (PRINGSH.)

Mycelium branched, septa rare; zoosporangia usually terminal, wall thin; resting conidia present in most species, terminal or interstitial; oogonium containing one spore; wall of oospore colourless.

Differs from *Saprolegnia* in the contents of the zoosporangia escaping before the cilia of the zoospores are formed, whereas in *Saprolegnia* the zoospores are fully developed in the zoosporangium.

Parasitic or saprophytic on plants or animals, mostly in water or very damp places.

All forms of reproduction in this genus are produced on the surface, never in the substance of the host.

'**Damping off.**'—This well-known term is used by gardeners to indicate the sudden collapse of seedling plants, evidently due to the shrivelling of the stem just above the ground line.

The injury to the stem is caused by a very minute parasitic fungus called *Pythium de baryanum* (Hesse).

Seedlings of crucifers are more especially liable to attack, but are by no means the only ones victimised, maize, clover, millet, cucumber, and probably all seedlings are liable to attack when conditions are favourable. Even the prothallus or youngest stage of such cryptogams as club-mosses (*Lycopodium*) and horse-tail (*Equisetum*) are attacked. Finally, stored potatoes, where 'sweating' has occurred, have been attacked.

Zoosporangia globose or broadly elliptical usually papillate, terminal or intercalary; resting conidial globose, terminal or intercalary, 20-25 μ diam. Oospores globose, colourless, smooth, 15-18 μ diam., producing a germ-tube on germination.

Although this disease is considered as a scourge by almost every gardener, yet in truth its occurrence is invariably due to neglect. It can only possibly exist where seedlings are too densely crowded, or where seed-beds are located in damp, stuffy localities. The fungus cannot exist in open ground exposed to wind and sunshine.

Soil that has produced a diseased crop should be sterilised.

De Bary, *Bot. Ztg.*, (1881) p. 357.
Marshall Ward, *Quart. Journ. Micr. Soc.*, 23, p. 487 (1883).

Bud-rot of palms.—During the past few years a peculiar disease attacking palms in the Godavari delta, India, has been investigated by Dr. Butler, Imperial Mycologist, Re-

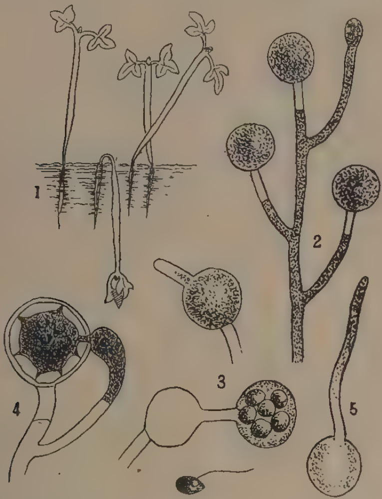

FIG. 23.—*Pythium de baryanum.* 1, seedlings of cress (*Lepidium sativum*) attacked by the fungus; 2, mycelium bearing conidia at the tips of the branches; 3, sporangia in different stages, also a free zoospore; 4, an oosphere with the antheridium or male organ, which has pierced the wall of the oosphere, and inserted a slender tube for the purpose of allowing the contents of the antheridium to mingle with those of the oosphere. After this blending of the contents of the two organs, the oosphere becomes surrounded by a thick wall to form the oospore, or sexually produced resting-spore; 5, a germinating conidium. Fig. 1. nat. size; remainder highly mag.

search Institute, Pusa. The palmyra palm (*Borassus flabellifer*) suffers most, but the cocoanut palm is also attacked. The symptoms are such that the disease can be recognised fairly easily. The earliest sign is the turning white of one of the leaves recently expanded, towards the centre of the bud; withering follows. Other leaves are attacked in turn, and finally the whole top withers and falls off. The primary cause of disease is *Pythium palmivorum* (Butler). Irregular, sunken patches are formed on the leaf-sheaths, particularly in the

inner layers, white at first, then brown. These commence on the outer sheaths first, and gradually work inwards. The patches are dry at first, and sometimes covered with a felt of white mycelium. At a later stage a wet rot follows, other organisms join in the act of destruction, and the primary cause is lost sight of.

Forming large patches of felty white mycelium on the inner surfaces of the leaf-sheaths. Sporangia inverted pear-shaped, less frequently globose, formed in the weft, and not raised on special sporangiophores, averaging $50 \times 35\ \mu$; zoospores after coming to rest, 8-10 μ. Oospores globose 35-45 μ, formed in the weft of mycelium, always extra-matrical.

When a tree is once attacked, recovery is hopeless, hence the head of every infected tree should be cut off and burned at the earliest stage of disease; by such means infection of other trees would be prevented. This method should be general to be of any real service. Healthy trees in the neighbourhood of infected ones should have leaf-sheaths brushed with Bordeaux mixture just before the removal of diseased trees commences.

A somewhat similar bud-rot of cocoanut palms is also prevalent in Cuba and the West Indies, also in Ceylon. By some this is considered as a bacterial disease, by others as due to a fungus. The cause will probably be proved, when thoroughly investigated, to be the same as the Indian one. All are agreed that the preventive method given above is the most certain if thoroughly carried out.

Butler, *Agric. Journ. of India*, 1, p. 304 (1906).

Pythium intermedium (De Bary). This fungus has been recorded as proving very injurious to the prothalli of ferns, especially when raised from spores and grown under glass. The fungus enters the tissue of the prothallus, which soon wilts, becomes dark in colour and dies. Rare in this country.

Conidia globose, terminal in chains of 2-5, the terminal one largest. Sexual reproduction unknown.

'If the pots or vessels in which the prothallia are grown are rested on sphagnum, a layer of which can be placed in the bottom of the Wardian case, and after the young prothallia have started, all of the watering be applied through this, the prothallia will do much better than if surface watering is practised, and far better than where the pots are rested in a

vessel full of water. The air of the Wardian case or of the house should not be kept too damp.'

Atkinson, *Cornell Agric. Expt. Station*, *Bull.* No. 94 (1895).

PERONOSPORA (Corda)

Haustoria filiform, branched, conidiophores emerging through the stomata of the host; conidia elliptical, apex rounded, germination by the lateral protrusion of a germ-tube. Oospores produced in the substance of the matrix.

All the species are parasitic on plants, mostly on leaves. Distinguished from allies by the filiform, branched haustoria, and absence of a papilla at the apex of the conidium.

A. *Wall of oospore smooth.*

Onion mildew.—This is due to the ravages of *Peronospora Schleideni* (Ung.), and is present in greater or less quantity wherever onions are cultivated, and what is also important to remember, it grows on various wild kinds of *Allium*. The first indication of disease is the presence of small white patches of mildew on the leaves, which within a couple of days change to a greyish-lilac colour, and present a minutely furry or velvety appearance. The side of the leaf opposite to the patch of mould changes to a sickly yellow colour. When once the mildew appears, if atmospheric conditions are favourable, it spreads rapidly. A few days after the leaves are first attacked they become dry, droop, and die, and a 'neck' or elongation of the plant between the bulb and the leaves is a constant feature of the disease. The bulb is not attacked, but if the disease appears somewhat early during growth its size is much reduced.

The conidial stage forms a dull lilac mould on the leaves; the conidiophores emerge in small numbers through the stomata, and are erect and much branched near the top; the conidia are borne at the tips of curved branches, slightly obovate, apex often more or less acute, pale, dingy lilac, $40-55 \times 20-25$ μ. Oospores broadly elliptical or globose, epispore thin, smooth, coloured.

If onions are grown on land that has previously produced a diseased crop, the probability is that the disease will appear almost simultaneously over the greater part of the plot. On

the other hand, if the land is not infected, if the disease appears it is in one or more isolated patches, and no effort should be spared to check the spread of the disease by removing the diseased plants, and spraying the surrounding onions. As previously stated, an epidemic of disease depends

FIG. 24.—*Peronospora Schleideni.* 1, a conidiophore that has emerged through a stoma of an onion leaf; 2, free conidia; 3, oospore or resting-spore. All highly mag.

almost entirely on weather conditions; when the disease is already present a few bright, dry days will cause its almost entire disappearance, the onions will again begin to grow, and will be but little the worse for the check. On the other hand, a continuance of damp, dull weather proves disastrous.

As a continuance of favourable weather cannot be depended upon, it is imperative that spraying should promptly follow the appearance of the disease. Bordeaux mixture may be used, half strength, but lime water should be used in its preparation, otherwise the leaves are apt to be scorched. Experiments conducted by me at Kew proved that three per cent. of sulphate of iron dissolved in water can be used for spraying onions without injuring the leaves, and this preparation is quite as effective against mildew as Bordeaux mixture, and is both cheaper and more easily prepared. The sulphate of iron must be pure. As resting-spores are usually produced in abundance in the leaves, and as such leaves fall soon after infection, it is certain that the land will be infected. In this case onions should not be grown on the land for some years afterwards. Good drainage is a check to disease.

Shipley, A., *Kew Bull.* No. 19 (Oct. 1887).
Whetzel, H. H., *Cornell Agric. Exp. Sta.*, *Bull.* No. 218 (1904).

Clover mildew, caused by *Peronospora trifoliorum* (De Bary), attacks all kinds of cultivated clover and lucerne, also wild leguminous plants belonging to the following genera: *Coronilla*, *Lotus*, *Lupinus*, *Medicago*, *Ononis*, and *Trifolium*. As a rule when a plant is attacked the entire under surface of the leaves becomes covered with a dense, dingy, lilac mildew. Such leaves turn yellow and fall quickly.

Conidiophores repeatedly branched, ultimate branchlets pointed and slightly curved, conidia elliptical, obtuse, 20-30 $\times$ 15-20 μ. Oospores globose, smooth, brown, 25-40 μ diam.

When a crop is once infected the disease spreads rapidly if the weather remains warm and moist, whereas a spell of bright dry weather often stamps out the disease.

If the pest spreads it is best to cut the crop before oospores are formed and the leaves fall to the ground.

Beet and mangold mildew (*Peronospora schachtii*, Fuckel) is responsible for much injury to beet and mangolds. The younger central leaves are most frequently attacked, and in the case of seedlings growth is materially checked or more frequently the plant is killed outright. The mildew appears on the under surface of the leaves as delicate greyish patches.

If a given plant is only slightly injured during the first season, the mycelium hibernates in the crown of the root and infects the leaves the second season. For this reason roots that have grown in an infected plot should not be planted for the purpose of furnishing seed.

Conidiophores repeatedly branched, terminal branchlets straight, blunt, conidia ovate, tinged brown, 20-24 × 15-18 μ. Oospores globose, the thick wall smooth.

Closely related to *Peronospora effusa* (Rab.), differing more especially in the oospore having a perfectly smooth wall.

As oospores are produced abundantly in the tissue of the dead leaves, all diseased plants should be collected and burned. Rotation of crops should be followed in the case of land that has produced a diseased crop.

Peronospora affinis (Rossm.) forms delicate, dingy lilac patches of mildew on the leaves of *Fumaria officinalis*.

Conidiophores much branched, ultimate branchlets pointed, conidia elliptical, 22-26 × 15-18 μ. Oospores globose, wall brown, smooth.

Peronospora grisea (De Bary) occurs on plants of the order Scrophulariaceae, more especially on the speedwells (*Veronica*), where it forms dense, dingy, lilac tufts on the under surface of the leaves.

Conidiophores thick, many times branched, ultimate branches generally unequal in length and slightly curved, oospores elliptical, 25-30 × 15-22 μ. Oospores globose, wall thick, smooth, 30-40 μ diam.

Peronospora urticae (De Bary) forms small, dingy lilac patches of mildew on the under surface of nettle leaves.

Conidiophores repeatedly branched, branches wavy, ultimate branchlets pointed, curved, conidia broadly elliptical, 20-30 × 17-24 μ. Oospores globose, brown, smooth, 21-25 μ diam.

The conidia have generally a suggestion of a papilla at the apex.

Peronospora ficariae (Tul.). On many wild buttercups. Often covering the entire plant with a delicate greyish mildew.

Conidiophores repeatedly branched, ultimate branchlets usually curved, conidia broadly elliptical, 20-25 × 15-18 μ. Oospores globose, brown, wall almost smooth, 30-35 μ diam.

B. *Wall of oospore wrinkled.*

Poppy mildew (*Peronospora arborescens*, De Bary) often proves very destructive to cultivated poppies, and is also not uncommon on our wild species. On the larger cultivated species its effects are very evident; the mildew often almost entirely covers the under surface of the leaves with a thin, whitish, fluffy mildew. The stem and petals are also often attacked. Diseased plants soon change to a sickly yellow, and the leaves curl and eventually fall to the ground.

Conidiophores slender, repeatedly forked, ultimate branchlets very slender, pointed and curved, conidia subglobose, $15\text{-}24 \times 15\text{-}20\ \mu$. Oospores globose, wall brown, minutely striate, $25\text{-}35\ \mu$ diam.

I have proved by experience that no benefit is derived from spraying with either Bordeaux mixture or potassium sulphide. The only means of preventing an epidemic is to remove plants as soon as the disease is observed.

Wallflower mildew (*Peronospora parasitica*, De Bary) often exterminates whole beds of wallflowers, and also attacks many other cruciferous plants, both wild and cultivated. When wallflowers are attacked, every part of the plant soon changes to a sickly yellowish-green colour, the stem is usually swollen and more or less curved, as are also the leaves, and every part is more or less covered with a delicate white mildew. Oospores are formed in profusion in the tissues.

Conidiophores thick, soft, wavy, repeatedly branched, ultimate branchlets fine pointed, curved, conidia broadly elliptical, $20\text{-}25 \times 16\text{-}20\ \mu$. Oogonia angularly globose, wall tinged yellow, very thick, slightly wrinkled, $25\text{-}45\ \mu$ diam.

Diseased plants can be readily recognised by the characters indicated above, and all such should be promptly removed and destroyed. When the disease has been present the land should not be planted with cruciferous plants for two or three years, otherwise infection would probably follow.

Spinach mildew (*Peronospora effusa*, Rab.) attacks cultivated spinach, and is also not uncommon on wild plants belonging to Chenopodiaceae, as goosefoot (*Chenopodium*), also on members of the dock (*Polygonaceae*) and violet (*Violaceae*) families.

The mildew forms dense, dingy lilac, broadly effused patches on the under surface of the leaves.

Conidiophores stout, repeatedly branched, ultimate branchlets pointed and curved downwards, conidia elliptical, 25-35 × 15-24 μ. Oospore globose, brown, wall irregularly wrinkled, 25-38 μ diam.

As spraying is practically impossible in the case of spinach, diseased plants should be promptly removed before the leaves fall, otherwise the numerous oospores present in the tissues of such leaves may infect plants the following season.

Peronospora violacea (Berk.) occurs on the petals of *Scabiosa arvensis*, where it forms pale lilac tufts.

Conidiophores very short, repeatedly branched, terminal branchlets short, erect, conidia elliptical, 30-40 × 16-20 μ. Oospores globose, brown, wall irregularly wrinkled, thick, 20-26 μ diam.

This species has vesicular haustoria.

Peronospora candida (Fuckel). This fungus forms delicate white, effused patches on the under surface of primrose leaves.

Conidiophores repeatedly branched, ultimate branchlets spreading, often slightly curved, conidia elliptical, 15-18 × 10-14 μ. Oospores globose, wall wrinkled, brown, 30-36 μ diam.

This fungus has occurred in Germany on the leaves of *Anagallis arvensis*, var. *coerulea*.

Violet mildew, caused by *Peronospora violae* (De Bary), sometimes attacks the Neapolitan and the sweet violet under cultivation, and is also not uncommon on most of our wild violets. The under surface of the leaves becomes more or less covered with a somewhat dense coating of a dingy lilac mould. Such diseased leaves soon dry up and die, and the disease spreads rapidly in a dull, moist atmosphere. Oospores are quickly produced in the dying leaves, hence all diseased material should be removed and not allowed to be on the soil.

Conidiophores rather short, repeatedly branched, ultimate branches pointed and turned downwards, conidia elliptical with a short apiculus, about 25 × 18 μ; oospore with a yellowish-brown, wrinkled epispore.

Recedes from *Peronospora* in having the conidia furnished

with a distinct apiculus or projecting wart at the apex, but typical of the genus in all other respects.

Plenty of air and sunshine and not too much water will arrest the disease.

Peronospora lamii (De Bary) is met with on labiate plants, as the dead nettles, *Stachys*, *Salvia*, etc., where it forms broadly effused, dingy lilac patches of mildew on the under surface of the leaves

Conidiophores short, several times branched, ultimate branches generally long and pointed, 17-25 × 15-20. Oospores globose, brown, 30 μ diam., wall slightly wrinkled.

C. *Wall of oospore warted.*

Peronospora arenariae (Tul.) is met with on caryophyllaceous plants, as chickweeds, stitchworts, etc.

Conidiophores slender, repeatedly branched, ultimate branchlets very slender, straight, conidia elliptical, 20-25 × 14-16 μ. Oospores globose, brown, wall with rather large warts, 24 × 30 μ diam.

D. *Wall of oospore netted.*

Peronospora viciae (De Bary) grows on the leaves of leguminous plants, as broad beans, various wild vetches, *Orobus*, *Melilotus*, etc. The mildew often forms a dense greyish felt on the under surface of the leaves.

Conidiophores repeatedly branched, ultimate branchlets pointed, short, conidia elliptical, 25-28 × 15-18 μ. Oospores globose, pale brown, wall with a wide meshed network.

Peronospora myosotidis (De Bary) occurs on boraginaceous plants, *Myosotis*, *Symphytum*, *Lithospermum*, etc.

Conidiophores slender, elongated, much branched, terminal branchlets very slender, conidia elliptical, 20-24 × 14-18 μ. Oospores globose, brown, wall with a large meshed network, 25-30 μ diam.

Peronospora calotheca (De Bary) occurs on plants belonging to Galiaceae, as species of *Galium*, *Asperula*, *Sherardia*, etc.

Conidiophores many times branched, ultimate branchlets, very slender, conidia elliptical, 25-30 × 14-17 μ. Oospore globose, brown, wall with a fine meshed network.

E. *Oospores unknown.*

Rose mildew (*Peronospora sparsa*, Berk.) has only been met with up to the present on cultivated roses, and the injury occasioned by its presence is often of a most serious nature, even when it does not assume the proportions of an epidemic. Young stock often suffers severely without any obvious cause, as the mildew is so minute and scattered, not forming evident downy patches as in other species, but only to be discovered when carefully searched for on the under surface of young leaves or shoots, with the aid of a good pocket-lens. The leading symptoms of its presence are as follows; young vigorous leaves suddenly begin to droop, and fall at once if the shoot bearing them is slightly shaken, the shoot also soon becomes limp and dies back. If diseased leaves or shoots are examined, blackish or reddish stains will be observed at various points, and on these stains a pocket-lens will reveal the presence of the parasite. If the disease continues unchecked older branches become infected; in fact no part of the plant having green living bark is safe from attack. I have reason to believe that the disease known as 'black mildew' by rosarians is caused by the parasite under consideration.

Conidiophores scattered, repeatedly forked; ultimate branchlets pointed, generally curved; conidia broadly elliptical, very obtuse, $17\text{-}22 \times 14\text{-}17\,\mu$. Oospores unknown.

I recently visited an extensive establishment entirely devoted to the cultivation of roses, the primary object being to supply the London market with cut blooms. An epidemic of some kind had been slowly spreading from one house to another, and examination of material showed that *Peronospora sparsa* was the primary cause. As no previous outbreak of this pest had been experienced, the means of prevention was uncertain, and the use of Bordeaux mixture was advised. The owner's account of his struggle and final victory is as follows: 'I followed your instructions, spraying the plants thoroughly with Bordeaux mixture for some weeks. This appeared to have very little effect, for the disease slowly spread into the remainder of the houses which had been clean.

'Feeling thoroughly disheartened (for I had then lost the crop from twenty-four houses), I decided to try very drastic measures. After thoroughly drenching a house with cupram,

I tried Campbell's Sulphurator, three times as strong as we usually use them (while the plants were still wet). This of course literally whitened everything with sulphur.

'Two days later I repeated this treatment, and although this house had the disease very badly, I scarcely saw another leaf fall. In fact leaves which previously would have fallen at the slightest touch, now seemed firmly fixed to the plants. I then applied this treatment to the other houses with equally satisfactory results. The plants broke afresh in a few weeks' time with quite clean foliage, since which I have kept them clean with light doses of sulphur.'

Tobacco mildew (*Peronospora hyoscyami*, De Bary) often proves very injurious to the tobacco crop in different parts of the world. In this country the fungus is not uncommon on the henbane, from whence it might at any moment pass on to allied cultivated plants belonging to the order Solanaceae. Forming very delicate greyish-brown patches on the under surface of the leaves. When attacked the leaves turn yellow and droop.

Conidiophores stout, tall, much branched, ultimate branchlets pointed, straight, conidia elliptical, $15\text{-}24 \times 14\text{-}18\ \mu$.

Spraying with dilute Bordeaux mixture is said to prevent the extension of this pest.

Colocasia disease (*Colocasia esculenta*, Schott), one of the Aroids, an important food plant in the West Indies, and known by one or other of the following local names in different islands, as 'Cocoes,' 'Tayas,' 'Tanias,' 'Tanniers,' 'Eddoes.'

The injury is due to a fungus called *Peronospora trichotoma* (Mass.), which attacks the tuber. In the early stage of the disease, a tuber when cut across shows a number of yellow dots or points, which correspond in position to the vascular bundles; these become darker in colour as the disease progresses, and finally the entire substance of the tuber, with the exception of a thin peripheral portion, becomes blackish in colour and decayed. At this stage the conidial stage appears as a delicate, dingy white mould on the surface, and oospores are abundant in the decayed tissue of the tuber. The disease attacks the tubers after they are lifted.

Mycelium thick, haustoria clavate; conidiophores fasci

culate, 2-3 times trichotomously branched; conidia small, obovate, or subglobose, $12 \times 10\ \mu$; oospore globose, epispore brown, with raised ridges anastomosing to form an irregular network, 35-40 μ.

The tubers should be thoroughly dried before storing. Only sound tubers should be used for propagation. Land that has produced a diseased crop should not be planted with colocasias again for two or three years.

Morris and Massee, *Journ. Linn. Soc.* (1887), p. 45.

Maize mildew (*Peronospora maydis*, Racib.) is responsible for a very serious disease of maize or Indian corn, which, so far as is known, is at present confined to Java. Young plants only appear to be attacked. As a rule the first two or three leaves are healthy, later ones becoming pale green, or more or less bleached, soon after which they droop and die. The conidiophores emerge from the tissue of the leaf through the stomata. The disease appears in twelve to eighteen days after a leaf has been intentionally infected. It is assumed that the disease has passed on to maize from some native grass, but this assumption has not yet been proved to be correct.

Conidiophores emerging through the stomata, 0·3 mm. high and up to 25 μ thick, with 1-3 main forking branches, which are divided at the tip into 3-6 conical pointed branchlets, each bearing a smooth, hyaline, globose conidium, 15-18 μ diam.; oospores globose, membrane smooth, 14-24 μ diam.

Oospores present in the soil are considered to be the principal cause of infection. This is probably due to diseased plants being left to rot and decay on the ground.

Raciborski, *Ber. d. deutsch. Bot. Gesell.*, 15, p. 475 (1897).

Cabbage and turnip leaf rot.—One of the downy mildews called *Peronospora parasitica* (De Bary) during certain seasons causes serious damage to turnips, cabbages, cauliflowers, radishes, wallflowers, and other cultivated plants belonging to the Cruciferae. Nearly all our wild plants belonging to this family of plants are also attacked, the shepherd's purse (*Capsella borsa-pastoris*) more especially suffering severely. The fungus appears as white downy patches on the under surface of the leaf, these patches increase in size until within

a few days the entire surface of the leaf is often covered. The disease spreads very rapidly when once introduced, and unless preventive measures are promptly applied the crop suffers severely, or may be completely destroyed. Schrenk, speaking of an epidemic caused by this fungus on cauliflowers grown under glass, says: 'The fungus made its appearance very suddenly, and within a week had spread over all the plants in the affected greenhouse, attacking both the old and the young leaves. So virulent was the attack that it looked for a time as if the whole crop would be destroyed.' It has also caused serious loss to growers of cauliflowers under glass in France. When wallflowers are attacked the leaves are somewhat stunted, rather fleshy, and inclined to grow erect.

This disease often accompanies white rust (*Cystopus candidus*,—Lév.).

The sporophores are stout and flaccid, irregularly 5-8 times divided into two or three branches, the branches repeatedly forked, the last lot of branchlets slender and curved; spores broadly elliptical, $20\text{-}22 \times 16\text{-}20\ \mu$, white. Resting-spores globose, smooth or becoming wrinkled, 26-43 μ.

Diseased plants should be sprayed with a solution of potassium sulphide. When spraying cabbages or cauliflowers it is important that the spray should come in contact with the under surface of the leaf. To secure this a pipe curved just below the nozzle should be used so that the spray can be directed upwards. All diseased leaves should be burned, otherwise the resting-spores will be set at liberty somewhere and at some time, and endanger other crops. Infected soil should be dressed with lime. Weeds of the crucifer family should not be tolerated in the neighbourhood of cultivated crops belonging to the same family.

Peronospora cytisi (Rostrup). This fungus causes brown specks to appear on the leaves of laburnum. The conidiophores are 4-5- times forked; conidia elliptical, clear brown, $20\text{-}28 \times 15\text{-}20\ \mu$. Oospores in the tissue of the leaf, 35-38 μ diam., wall 7-8 μ thick.

Rostrup, *Pflanzenkrankh.*, 2, p. 1 (1892).

Peronospora sordida (Berk.) forms broadly effused, dingy lilac patches of mildew on the under surface of leaves of species of *Scrophularia*, *Verbascum*, and *Digitalis*.

Conidiophores repeatedly branched, ultimate branches pointed and often curved, conidia elliptical $24\text{-}28 \times 15\text{-}20\ \mu$.

BREMIA (Regel)

Conidiophores branched, tips of branchlets expanded into a saucer-shaped disc bearing sterigmata at the rim, each producing one conidium ; oospores minute, brown, wall wrinkled. Haustoria simple, clavate.

Distinguished from allies by the distinctly dilated tips of the conidiophores.

Lettuce mildew, caused by *Bremia lactucae* (Regel), often proves very destructive to lettuce, more especially when grown under glass and in a humid atmosphere. The fungus appears as a very delicate white mildew on the under surface of the leaves. These soon become yellow, droop, and die. The disease spreads rapidly when conditions are favourable ; such conditions being a fairly high temperature and a humid atmosphere.

Conidiophores 2-6 times dichotomously forked, tips inflated and bearing several subglobose conidia $15-24\ \mu$; oospores globose, brownish, wrinkled, $25\text{-}35\ \mu$ diam.

In the case of lettuce spraying or the application of sulphur is out of the question. A lowering of the temperature and admission of air checks the spread of the disease. Infected leaves, which are easily recognised by the yellowish colour and wilting, should be removed at once before the spores are conveyed to other plants.

The fungus also attacks cinerarias, artichokes, and many of our wild plants belonging to the Compositae, as goat's-beard, sow-thistle, thistles, hawkweed, scabious, etc.

PLASMOPARA (Schröt.)

Haustoria ovate, unbranched. Conidiophores erect, comparatively sparingly branched, conidia elliptical, generally papillate at the apex. Oospores globose, wall coloured.

All species are parasitic on plants. Distinguished from *Peronospora* by the simple globose or ovate haustoria and the papillate conidia.

Grape mildew.—This very destructive disease, caused by

Plasmopara viticola (Berl. and de Toni), was introduced to Europe from the United States, where it is equally injurious to both wild and cultivated vines. Every portion of the plant above ground is attacked, but more especially the foliage, where its presence is first indicated by the appearance of pale,

FIG. 25.—*Basidiospora entospora*. 2, 3, *Sclerospora graminis*, conidial stage and oospore ; 4, *Bremia lactucae*, portion of conidial stage. All highly mag.

yellowish-green patches on the upper surface of the leaf. Corresponding areas on the under surface soon become covered with a delicate greyish mildew ; these patches continue to increase in size, and run into each other, until finally the entire under surface is covered with mildew. Soon after this stage has been reached the leaf turns yellow, then brown, dries up and falls, but not before myriads of spores have been

liberated and dispersed throughout the house. Tendrils and parts of the flower behave in a similar manner when attacked.

FIG. 26.—*Plasmopara viticola.* 1, under surface of a vine leaf showing white patches of mildew; 2, group of conidiospores bearing numerous conidia; 3, three conidia more highly mag.; 4, conidia containing zoospores, in *b*, two zoospores have escaped from the conidium; 5, mature oospore or resting-spore; 6, an oospore germinating and producing a conidiophore (after Prillieux); 7, autumnal form of conidiophore bearing a few large conidia (after Prillieux). Fig. 1 reduced, remainder highly mag.

Oospores are produced in abundance in the dying portions of the plant.

When a plant is attacked, the fruit, even if not directly infected, suffers in consequence, and rarely matures, owing to

the loss of the foliage, and the entire plant is prevented from preparing the store of food necessary for next season's vigorous growth.

Conidiophores slender, branched near the apex, ultimate branchlets pointed, straight, conidia elliptical, not papillate at the apex, very variable in size, smallest 8×12, largest up to 17×30 μ. Oospore subglobose, wall brown, thin, smooth or slightly wrinkled, 30-35 μ diam.

In many vineries the disease has been observed to first appear in one particular part of the house; this has been traced to draught or comparative lack of light and ventilation at that particular spot.

Spraying at intervals with dilute Bordeaux mixture until the grapes are set will check the spread of the disease. During the winter, when the vines are resting, thoroughly drench the plants, soil, and every part of the house with a solution of sulphate of iron. Remove all diseased leaves, and be particular to collect and burn all fallen leaves, etc.

Massee, *Gard. Chron.*, July 21, 1894.
Viala, *Les Malad. de la Vigne*, p. 57.

Cucumber and melon mildew (*Plasmopara cabensis*, Humphrey) often does serious injury to cucumbers, melons, and other plants belonging to the gourd family in the United States, and has also been recorded on cucumbers in this country. It forms a delicate mildew on the under surface of the leaves of a delicate lilac colour. The patches are small at first, but gradually encroach on each other, forming large areas. Affected leaves become yellow and shrivel up. The disease spreads rapidly during hot, moist weather, and is more prevalent on plants grown in the open than on those under glass.

Care must be taken not to confound the present disease with the cucumber powdery mildew, caused by *Erysiphe polygoni* (D. C.), as the two require different methods of treatment respectively.

Conidiophores repeatedly branched, ultimate branchlets pointed, straight, conidia elliptical, $25\text{-}32 \times 18\text{-}20$ μ. Oospore unknown.

Spraying with Bordeaux mixture at intervals of about ten days is said to hold the fungus in check.

Plasmopora entospora (Schröter) forms small, whitish tufts

of mildew on the under surface of the leaves of species of *Aster* and *Erigeron*.

Conidiophores cylindrical, whitish then tinged brown, apex slightly inflated, bearing a few slender sterigmata, each carrying an elliptical, papillate conidium, 20-25 × 12-14 μ. Oospore globose, wall thick.

Plasmopara pygmaea (Schröter). Forms minute tufts of mildew, white at first then greyish, on the under surface of leaves of *Aconitum*, *Anemone*, *Hepatica*, *Isopyrum*, and other ranunculaceous plants.

Conidiophores slender, simple or sparingly branched, tips with a few slender branchlets (sterigmata), each bearing an elliptical conidium, having the apex broadly and obtusely papillate, 18-25 × 15-20 μ. Oospore globose, wall brownish, smooth or minutely rugulose, 44-45 μ diam.

Plasmopara nivea (Schröt.). Grows on the under surface of the leaves of various umbelliferous plants, as *Aegopodium*, *Anthriscus*, *Angelica*, *Pimpinella*, *Sium*, *Daucus*, etc., etc.

Conidiophores simple or slightly branched, conidia broadly elliptical, apical papilla indistinct, 21-25 × 15-18 μ. Oospore irregularly globose, brownish, smooth or slightly rugulose.

The conidiophores sometimes are crowded and form a delicate white mildew on the leaves. The mycelium is known to be permanent in the root of some of the host-plants.

Plasmopara densa (Schröt.), is parasitic on the under surface of the leaves of *Bartsia odontites* and *Euphrasia officinalis*, where it forms small scattered white, then yellowish patches of mildew.

Conidiophores slightly branched, conidia broadly elliptical or subglobose, minutely and obtusely apiculate, 12-16 × 10 12 μ. Oospore globose, pale yellow.

SCLEROSPORA (Schröt.)

Conidiophores erect, simple or sparingly branched, conidia ovate, zoospores escaping through the ruptured apical papilla. Oospores globose, epispore brown, very thick, multistratose.

Sclerospora macrospora (Sacc.) has been recorded as occurring on the male flower of maize. Springing from the stomata dendritic tufts of mycelium were observed, which were considered to represent a hitherto unknown conidial condition of the fungus.

The oospores measured 52·3 μ, epispore pale yellow.

Peglioni finds that the dissemination of *Sclerospora* in cereals is effected by the presence of mycelium under the outer coating of the seed. Grains from a diseased head were sown without any treatment; some did not germinate, and those that grew presented abnormal characters, and microscopic examination showed the presence of mycelium in the younger parts of the plants.

Cugini, *Le Stazioni sper. agrar. Ital.*, 35, p. 46.
D'Ippolito and Traverso, *ibid.*, 36, p. 975, 996.
Peglioni, *Atti Reale Accad. Lincei*, 305, p. 509.

PHYTOPHTHORA (DE BARY)

Conidiophores emerging through the stomata of the host-plant, sparingly branched; conidia ovate, papillate, produced apically, producing zoospores. Oospores globose, epispore rather thin, smooth, brown.

The conidia or zoosporangia are in reality always acrogenous or apical, but when a conidium is formed at the apex, the conidiophore continues to increase in length, and bears another conidium at its apex, and this continues repeatedly; consequently many of the conidia appear to be developed laterally on the conidiophore.

The potato disease.—This terrible scourge, caused by *Phytophthora infestans* (De Bary) was noted at Boston, U.S., also in Denmark and Norway between 1840 and 1842, and by 1845 it had become general throughout Europe, doing immense damage. It is perfectly certain that the disease was imported to Europe, but why its advent was for so long retarded after the introduction of the potato, is a problem that cannot be solved. The same is the case with the hollyhock disease. The disease is well known in South America, the home of the potato. I observed it frequently in various parts of Ecuador in the patches of potatoes cultivated by the natives. Wherever the disease was introduced it appears perfectly certain that it came in the form of hibernating mycelium in the tubers. Oospores or resting-spores are unknown, and the conidia germinate at once on reaching maturity. Prillieux considers that when the potato was first introduced, the long period occupied by the voyage, and

consequent exposure to tropical conditions for so long a period, destroyed the hibernating mycelium; whereas when a quicker means of transit, due to the replacing of sails by

FIG. 27.—*Phytophthora infestans.* 1, a cluster of conidiophores with conidia, emerging through a stoma of the leaf of a potato plant; 2. a free conidium, the contents of which are breaking up into zoospores; 3. a conidium liberating zoospores; 4. a zoospore that has come to rest and is germinating; 5. a conidium germinating by the protrusion of a germ tube. All highly mag.

steam, became general, the hibernating mycelium present in the tuber survived the voyage.

The first indication of the disease is the appearance of small brownish blotches on the leaves; these quickly increase in size, and the leaves curl, and under favourable weather conditions for the fungus both stem and leaves become black

and rotten within a few days, emitting a very disagreeable smell. If a brown patch is examined with a pocket-lens, minute, white, mould-like bodies, the conidiophores of the fungus, will be seen on the under surface of the patch, more especially towards the margin. When the attack is slighter and the foliage is not destroyed at once, the conidia are produced in rapid succession, and are conveyed to neighbouring plants by rain, wind, animals, etc., and by such means the disease spreads rapidly. But, as I have proved, the simultaneous outbreak of an epidemic extending over wide areas is not due to infection by conidia, but to the presence of hibernating mycelium of the fungus present in the tuber. It has been stated that the zoospores produced in the conidia are washed down into the soil, and infect the young tubers. This statement, however, has not been proved, and I have not succeeded in infecting young tubers with conidia, even when placed under very favourable conditions for doing so. It has also been stated that the mycelium in an infected stem passes down into the young tubers. I have not succeeded in confirming this statement. On the other hand, I have proved by repeated experiments that when a diseased tuber is planted, the mycelium from such tuber passes into the young potatoes, which also become diseased, under circumstances where there was no possibility of conidia falling from the foliage on to the soil.

The brown stains on the surface of a potato infected with *Phytophthora* are too well known to require description. When the disease is very evident, probably no one would use such tubers for 'seed,' but there are numerous instances where the disease does not show on the surface, or is so slight that it is overlooked, and when such tubers are planted, the young tubers also become diseased, and thus the disease is passed from generation to generation in a vegetative manner, and without the formation of spores on the part of the fungus. The produce of a diseased tuber is always diseased, yet under certain conditions of weather the stem and leaves of the same plant may remain perfectly free from disease. This happens during bright, comparatively dry seasons, the mycelium in the tuber not being able to invade the above-ground portions. On the other hand, every practical potato-grower knows too well that a few cloudy, damp, and sultry days in July will start an epidemic of disease simultaneously over an entire field or over a whole district. The mycelium

favoured by the weather conditions indicated above, takes possession of the stem and leaves, which succumb within a few days. A German investigator has given it as his opinion that there is not a tuber free from disease, and the sudden outbursts, favoured by suitable weather, support his statement.

Mycelium slender, aseptate, haustoria rare, conidiophores solitary, or 2-5, emerging through the stomata, simple or sparingly branched above, tapering upwards, with scattered knots above, corresponding to the origin of the conidia, up to 1 mm. high, forming a delicate white mould on the leaf; conidia lemon-shaped, colourless, with a prominent papilla, $25\text{-}30 \times 15\text{-}20\ \mu$, producing on germination 6-16 baciliate zoospores.

Sexual mode of reproduction arrested, hence there are no oospores or resting-spores. The bodies described by Smith as oospores of this species were proved to belong to a species of *Pythium*.

Much has been written on the subject of prevention or cure of this disease, but actual results are poor, as would be expected, now that we know that the great bulk of disease is due to hibernating mycelium in the tubers, against which no remedy is known. By means of this hibernating mycelium present in the tubers, the disease is conveyed from one district, and from one country, to another. Potatoes from a crop known to be diseased should never be used for 'seed.' Spraying with Bordeaux mixture has proved beneficial, inasmuch as it prevents the amount of infection that would be caused by conidia, but unfortunately it has no control over the entry of mycelium into the young tubers. Bordeaux mixture is also said to invigorate the foliage, and causes it to continue in a healthy condition for a longer period of time than when not sprayed.

The many attempts to produce varieties of potato immune to this disease leave much to be desired.

De Bary, *Journ. Roy. Agric. Soc. Engl.*, 12 (1876).
Jensen, *Mem. Soc. Agric.*, 131 (1877).
Massee, *Kew Bull.*, No. 4 (1906).
Prillieux, *Malad. des Plantes Agric.*, 1 p. 78 (1897).
Ward, *Diseases of Plants*, p. 59.

Beech seedling mildew.—This disease is caused by

Phytophthora omnivora, De Bary (= *Phytophthora cactorum*, Schröt.). Hartig has paid special attention to this fungus, more especially as a parasite attacking beech seedlings, although as one of its specific names indicates, it also attacks other plants, more especially in the seedling stage, among

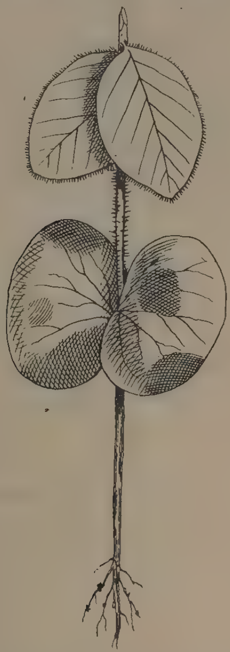

FIG. 28.—*Phytophthora omnivora*. A beech seedling attacked by the fungus. The dark portion of the stem below the cotyledons, and the blotches on the cotyledons, are caused by the mycelium present in the tissues.

which may be mentioned *Cactus*, *Acer*, *Fraxinus*, *Robinia*, *Fagopyrum*, *Sempervivum*, *Clarkia*, and various conifers.

In seedlings, the appearance of dark-coloured blotches on the cotyledons or the primary leaves indicates the presence of the fungus; dark patches also frequently occur on the stem below the cotyledons, and when this is the case recovery is

impossible, whereas if the leaves only are attacked, the plant may recover. Gaps are often made in seed-beds by this fungus, which spreads rapidly when once introduced. The extension of the disease is favoured by damp weather, and is retarded by drought.

In this species the mycelium is furnished with minute, roundish haustoria, which pierce the cells and absorb nourishment. Lemon-shaped, papillate conidia are produced on the surface of diseased portions. These are conveyed by wind, rain, animals, etc., to neighbouring plants, where they germinate, enter the tissues, and extend the disease. Sexually produced oospores or resting-spores are also formed in the tissues of the host-plant.

Hyphae variously branched; conidiophores slender, simple, or sparingly branched, often nodulose at intervals below the apex; conidia lemon-shaped, $50\text{-}60 \times 35\text{-}40\ \mu$, liberating on germination up to 50 zoospores; oospore globose, smooth, yellowish-brown, $24\text{-}30\ \mu$ diam., often in clusters.

Seed-beds should be freed from shade if the disease appears, as if the young plants dry quickly the conidia are prevented from germinating. All diseased plants should be carefully and promptly removed and burned. Hartig states that oospores retain their vitality for four years, hence land that has borne diseased plants should not be used again.

De Bary, *Beitr. Morphol. u. Phys. der Pilze* (1881).
Hartig, *Unters. aus dem Forstbot. Inst.* (1880), p. 33.
Hartig and Somerville, *Diseases of Trees*, p. 38.

Cacao-pod disease.—This disease, caused by *Phytophthora omnivora* (De Bary) has been present for a considerable time in the West Indies, but of late years has become much more general and destructive in Trinidad. The same disease has been proved to be present on cacao-pods in Ceylon, and is probably present to some extent wherever cacao is cultivated. The fruit is the part attacked, and the symptom of disease is a blackening of the 'shell' of the pod, which almost invariably commences at one end, and gradually spreads over the entire surface. After a while the fruit of the fungus appears on the surface of the shell as a very delicate white mould, located mostly in the furrows of the shell. The white mould represents the conidial fruit of the fungus, and continues to produce fruit for some time,

which, being dispersed by wind and rain, infects neighbouring pods. The mycelium of the fungus permeates the entire substance of the shell, and often also attacks the seeds. Numerous resting-spores are produced in the diseased tissues, and are liberated when the shell decays. These resting-spores then germinate and produce the conidial form of fruit, which commences the disease afresh another season. This disease must not be confounded with the indurated pods of cacao, caused by *Colletotrichum lusificum* (Hall and Drost), which causes a black, hard patch on the shell, and is common in Surinam and Demerara. Hyphae very slender, irregularly branched, haustoria absent; conidiophores slender, simple, or sparingly branched, often nodulose at intervals below the apex, corresponding to points that have borne conidia; conidia lemon-shaped, 50-60 × 35-40 μ, liberating up to fifty zoospores on germination; oospores globose, smooth, yellowish-brown, 24-30 μ diam., often in clusters.

Spray with dilute Bordeaux mixture when the pods are quite young, and continue at intervals, depending on the weather.

Remove all diseased pods from the tree, and burn or bury them, as the fruit never matures when attacked.

The accumulations of old diseased shells, so commonly met with in plantations, are a veritable hot-bed of disease, and should be destroyed.

The fungus attacks a large number of different kinds of plants, more especially in the seedling stage. Seedling cacao trees are often attacked.

Low-lying, damp situations, and heavy shade favour the disease.

Massee, *Kew Bull.* (1889).

Black rot of betel-nut palm.—Dr. Butler describes a disease of the betel-nut palm (*Areca catechu*), prevalent in the Malnád districts of Mysore.

The first symptom appears at the time of flowering; many of the flowers fall without setting fruits, and the stalks blacken and putrefy. The disease spreads along the inflorescence, and causes the nuts that are forming to drop at an early stage. The injury gradually extends through the leaf-sheaths until finally the growing-point in the centre of the bud is reached, which is also destroyed, and the whole head

withers and falls off. The injury is caused by a species of *Phytophthora*, which, however, is not described.

Two preventive methods are indicated. (1) To revert if possible to the late harvested crop of former years. (2) A more efficient method of prevention is the improvement of the covers used for the bunches. The leaf covers used are tied over the bunches as soon as the rains begin. These dry and crack in fine weather, and during long continued rains rot and fall to pieces. The substitution of tin covers is recommended.

Butler, *Agric. Journ. of India*, 1, p. 299 (1906).

Lima bean mildew (*Phytophthora phaseoli*, Thaxter) is the cause of serious injury to the Lima bean (*Phaseolus lunatus*) in the United States. The pods more especially are attacked, white felty patches of mould frequently cover the entire surface. The young shoots are also swollen and distorted. Less frequently it also develops on the leaves and petioles.

Conidiophores springing singly or in clusters through the stomata, strongly swollen at the base, simple or sparingly branched upwards, tapering, with scattered, swollen portions above, corresponding to the origin of conidia, up to 1 mm. high; conidia lemon-shaped, with a prominent papilla, hyaline, $25\text{-}30 \times 15\text{-}20\ \mu$, producing on germination 6-16 zoospores.

Dilute Bordeaux mixture checks the spread of the disease.

Thaxter, *Bot. Gazette*, 14, p. 273 (1889).

CYSTOPUS (Lév.)

Sori or groups of conidiophores produced under the epidermis of the host, bursting through when the conidia are mature. Conidiophores in dense clusters, short, each bearing a chain of superposed conidia. Conidia all alike, colourless, and producing zoospores, or the terminal conidium larger than the rest, and either sterile or producing a germ-tube on germination. Oospores globose, coloured, producing zoospores on germination.

As both conidia and oospores produce zoospores on

germination, these fungi can only infect plants during the presence of a certain amount of moisture. All are parasites on plants.

White rust of crucifers.—This fungus (*Cystopus candidus*,

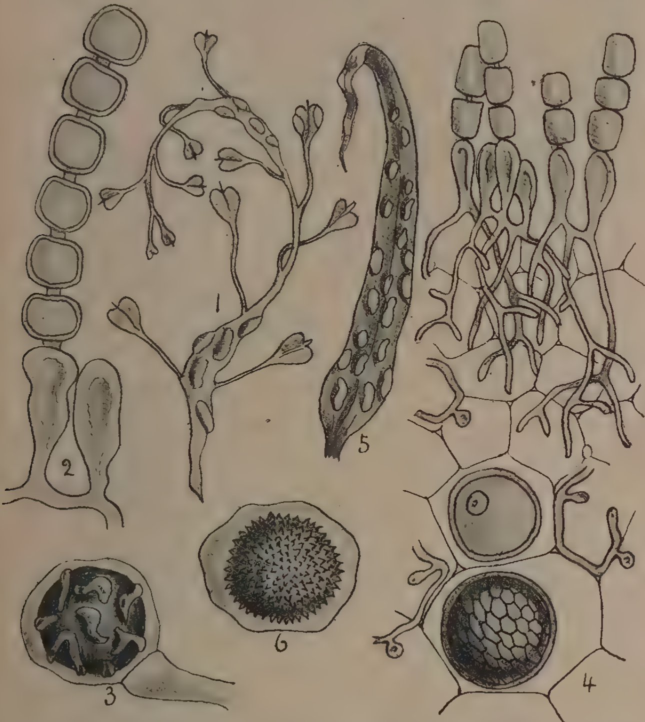

FIG. 29.—*Cystopus candidus.* 1, fungus on shepherd's purse; 2, conidial form of fruit; 3, oospore; 4, *Cystopus portulacae*, conidia and oospores in various stages of development; 5, *Cystopus trogopogonis*, on leaf of goat's-beard; 6, oospore of same. Figs. 1 and 5, nat. size; remainder highly mag.

Lév.) attacks nearly all plants belonging to the crucifer family, in every part of the world. Among species of economic value may be enumerated: horse-radish, radish,

cabbage, cress, and among weeds the shepherd's purse suffers most severely. The fungus attacks the plants when seedlings, entering into the tissues through the stomata of the cotyledons or seed-leaves. The mycelium grows up with the plant, and at a later stage produces fruit on leaves, stem, and flowers alike. When the stem and inflorescence are attacked they usually become much distorted and curled; the same also applies to the fruit. The fruit of the fungus first appears at the surface of the host as snow-white, polished patches which soon become powdery as the conidia mature and become free.

Conidia forming the chains all similar in size and shape, globose, 10-16 μ diam. Oospores subglobose, brownish, wall with large warts which sometimes run out into ridges 35-45 μ diam.

If it is remembered that the infecting bodies are zoospores, can only make progress when a film of moisture is constantly present on the host-plant, and further that infection can only be effected during the seedling stage of the host, it will be seen that seed-beds should occupy a fairly dry, open situation.

As oospores are usually produced in abundance, all diseased plants, as far as practicable, should be removed and burned. Finally cruciferous weeds, more especially shepherd's purse, should be kept down.

Cystopus tragopogonis (Schröt.) forms white patches on the leaves of goat's-beard (*Tragopogon pratensis*), also on *Convolvulus* and *Ipomaea*.

The white sori or pustules are often grouped in broken concentric rings. Terminal conidium of chain larger than remainder, thick walled, sterile, remainder of conidia shortly cylindrical, each with a transverse thickened ring, 19-23 μ. Oospore globose, brown, with large wrinkled warts, 45-60 μ diam.

Var. *spinulosus* forms white patches on thistle leaves, and is distinguished by the elongated conidia, and the very prominent warts on the wall of the oospore often bearing outgrowths or spines.

Cystopus lepigoni (De Bary) forms minute yellowish patches on leaves of plants belonging to Caryophyllaceae, as *Spergula*, *Arenaria*, etc.

Terminal conidium of the chain larger than the rest, sterile, remainder nearly globose, 18-21 μ. Oospore

globose, brown, wall covered with numerous minute warts which are sometimes more or less spinulose, 45-55 μ diam.

RHIZOPUS (Ehr.)

Vegetative hyphae long, creeping, giving off at intervals fascicles of erect sporangiophores, and tufts of rhizoids that enter the substratum, whitish then coloured; sporangia globose furnished with a columella, spores numerous, coloured. Zygospores produced in the substratum, suspensors short, stout, without branches.

Characterised by the long, coloured, creeping threads, which at intervals produce tufts of erect aseptate sporangiophores bearing sporangia, and numerous rhizoids which penetrate into the matrix on which the fungus is growing.

Japan lily disease.—Some years ago several consignments of bulbs of *Lilium speciosum* and *L. auratum*, received from Japan, were found to be mostly diseased when received in this country. Samples of these were submitted to Kew for examination, and were found to be attacked by a fungus which proved to be a new species, and was named *Rhizopus necans* (Mass.).

The fungus appears to be a wound parasite, and first effects an entrance through injured or broken roots, afterwards spreading upwards into the bulb-scales until finally the entire bulb is permeated with mycelium and becomes discoloured. When diseased bulbs become rotten they are soon covered with a dense white weft of mycelium, from which spring numerous clusters of sporophores bearing black, globose sporangia. Oospores are also produced in the decaying bulb-scales.

Fasciculate sporangiophores springing from white felted mycelium, simple or forked, coloured, sporangia globose, blackish, columella large, subglobose, spores pale olive-brown, minutely stricate, 5-6 μ. Zygospore dark, wall covered with spinous warts, 100-120 μ.

The fungus can also live as a saprophyte on the ground, and infection probably generally takes place when the bulbs are lifted. If suspected bulbs are submerged in a one per cent. solution of salicylic acid for half an hour, any spores or mycelium present are killed. Bulbs should be thoroughly dry

FIG. 30.—*Rhizopus necans.* 1, section of a diseased lily bulb, the dark portion of the base of the bulb is the part attacked by the fungus; 2, fruiting condition of the fungus growing on the root of a bulb; 3, cluster of sporangia of the fungus; 4, cluster of sporangia more highly mag.; 5, optical view of a sporangium; *a*, columella, the portion *b*, between the columella and outer wall is filled with spores; 6, spores, some of which are germinating; 7, spores more highly mag., showing the markings on the epispore; 8, zygospore; 9, mycelium of the fungus running between cells filled with starch. Figs. 1 and 2 nat. size; remainder mag. (From *Kew Bulletin*).

before packing, for if sweating occurs the smallest trace of disease will spread rapidly.

Bulbs should not be planted where the disease existed the previous season, unless the land has been sterilised.

Massee, *Kew Bulletin*, p. 87 (1897).

Rhizopus nigricans (Ehr.) is also said to attack bulbs at times, although usually a saprophyte. It has also been stated to cause a soft rot of sweet potatoes in the United States. Forming thin, effused tufts which are whitish at first then blackish olive.

Sporangiophores in clusters, erect, aseptate, springing from long, creeping stolons, rhizoids numerous at the points from which sporangiophores spring. Sporangia globose, blackish-olive, granular, columella hemispherical, spores grey, subglobose, or elliptical, 11-14 μ. Zygospore 150-200 μ, wall brown, with rounded warts.

Halsted, *New Jersey Agric. Coll. Expt. Station*, *Bull.* No. 76.

ASCOMYCETES

The one constant feature of the members constituting the present group is the production of the spores in specialised cells or asci. The most frequent number of spores contained in an ascus is eight.

EXOASCACEAE

This is structurally the most primitive of families included in the Ascomycetes, and in this respect is analogous with the family Exobasidiaceae amongst the Basidiomycetes. In some species the mycelium is only present between the cuticle and epidermis of the leaf or fruit upon which it is parasitic. In other species the mycelium penetrates deeper into the tissues, but is always intracellular, haustoria never penetrating the cells. In all instances the mycelium accumulates between the cuticle and the epidermis, and there produces numerous asci, which rupture the cuticle and develop on the surface of the host. These asci are not enclosed in a receptacle of any kind whatever, but are fully exposed to the air. They are usually densely packed side by side like the cells of the

palisade tissue of a leaf, and as seen to the naked eye give a delicate bloom-like appearance to the surface they are seated

FIG. 31. 1, *Exoascus deformans*, showing asci in various stages of development bursting through the cuticle of the leaf; 2, ascus of *Exoascus pruni*, showing stalk-cell at base of ascus, and eight spores; 3, ascus of *Taphrina aurea* filled with secondary spores produced by budding of the ascospores; 4, surface view of mycelium of *Taphrina Sadebeckii* on leaf of *Alnus glutinosa*; 5, differentiation of fertile or ascogenous hyphae from vegetative hyphae of *Taphrina Sadebeckii*. (Figs. 4 and 5 after Sadebeck.) All highly mag.

upon. The asci at first contain eight spores, but in the majority of instances these spores germinate in the ascus, by the process of budding or germination, as in yeasts,

thus producing numerous, minute, secondary spores which completely fill the ascus.

The two most important genera, *Exoascus* and *Taphrina*, are parasites, and in many instances do a considerable amount of damage, causing distortion of leaves or fruit, or forming dense tufts of branches known as 'witches' brooms' or 'crows' nests,' from their general appearance. These structures are characterised by a dense tuft of branches springing from a single, more or less swollen point on the branch from which they originate. The branches of a broom are usually more or less thickened and densely branched, and grow in a vertical direction, hence such tufts are very conspicuous, springing as they usually do from more or less horizontal branches. Brooms never produce flowers, and the leaves are often much modified, being thicker in substance than normal leaves, contain less chlorophyll, and are often more or less crumpled or distorted. Asci are produced on the leaves, and the mycelium hibernates in the shoots. Brooms sometimes assume large proportions, and add to their size year by year.

It is important to bear in mind the fact that witches' brooms are in some instances produced by members of the Uredinaceae or rusts, in others by mites. Not infrequently brooms, caused by fungi and mites respectively, occur on the same tree, as in the common birch, or on the same tree, both mites and fungi may be present on the same broom.

The distinction between the genera *Exoascus* and *Taphrina* is based entirely on biological grounds, there being no marked morphological distinction between the two.

In *Exoascus* the mycelium is perennial in the young shoots of the host-plant, consequently there are two modes of reproduction: (1) by resting mycelium in the branches, which passes into the buds, and finally develops in the leaves or fruit; (2) by means of spores which are distributed by wind, birds, insects, etc., thus enabling the fungus to attack new hosts and extend its area of distribution.

In the genus *Taphrina*, the mycelium is only annual in duration, hence infection by spores is the only means of perpetuating the species from year to year.

The species in this group, apart from the host-plant, are not very clearly marked.

Massee, Geo., *British Fungus-Flora*, 4.

EXOASCUS (FCKL.)

The species often produce witches' brooms, or distortions of the fruit or leaves. Mycelium perennial in the tissues. Asci produced on the leaves or fruit.

Many species are very destructive parasites.

Peach leaf-curl, due to *Exoascus deformans* (Fckl.), attacks the leaves of peach and almond. Diseased leaves are much

FIG. 32.—*Exoascus deformans.* 1, peach leaves curled by the fungus; 2, section showing asci on the surface of a leaf; 3, spores producing secondary spores by budding. Fig. 1 reduced; remainder highly mag.

puckered, crumpled, and twisted, at first pale green, becoming more or less rosy and covered with a delicate whitish bloom, due to the presence of numerous asci.

The mycelium hibernates in the bark, medullary rays, and pith of young shoots, and extends along with the growing parts, from which it passes into the leaf-buds, and infects the leaves each succeeding season.

The only certain method of eradicating this disease is by removing all infected shoots. Spraying with Bordeaux mixture has many advocates, but the fact remains that the perennial mycelium present in the shoots produces a crop of diseased leaves each year, in spite of spraying. Spraying will undoubtedly prevent infection from spores, but if the cause of infection is removed by cutting away infected shoots, no spores would be forthcoming to infect healthy shoots.

Plum-pockets, caused by *Exoascus pruni* (Fckl.), occur on the cultivated plum, and on the wild bird-cherry (*Prunus padus*). The fruit is the part attacked, and the presence of the disease can be detected about three weeks after the blossom has fallen. The mesocarp is stimulated to excessive growth, whereas the embryo and stone of the fruit are almost entirely arrested. During the course of growth, infected fruits become very irregular in form, often curved, and more or less hollow, colour at first pale, sickly green, then red or purplish, surface usually much wrinkled.

The crowded asci form a delicate bloom on the epidermis of the plum-pocket.

The mycelium of the fungus is perennial in the soft bast of shoots, which are often thickened and twisted in consequence. From the shoots the mycelium passes into the flower-bud and infects the ovary. The stamens and calyx also often show signs of the presence of the fungus.

The shoots are infected by spores produced on the diseased fruit.

Branches bearing diseased fruit should be removed, as the perennial mycelium continues to infect the fruit each succeeding season.

Witches' brooms of cherry, produced by *Exoascus cerasi* (Fckl.), are by no means uncommon on wild and cultivated cherry-trees. The branches grow more or less erect and are crowded together, resembling a besom or broom, and are often of large size. In some instances the broom is pendulous, with the tips of the branches more or less upturned. The leaves are only slightly crumpled, much thicker than normal leaves, pale green or often reddish. and fall early in the season. The asci are produced on the under surface of the leaves. The mycelium of the fungus can be more readily seen in this species than in most others, and can be detected

between the cells of the leaf, and in the bark, medullary rays, and pith of the shoots.

The brooms should be removed both from cultivated and wild trees.

Witches' brooms of birch, produced by *Exoascus turgidus* (Sadeb.), are very abundant in this country on *Betula verrucosa*,

FIG. 33.—*Exoascus pruni*. 1, portion of a branch bearing diseased plums; 2, a diseased plum cut in two. Reduced.

and closely resemble crows' nests in appearance, although sometimes much larger in size. The formation of these brooms takes place as follows, according to Smith:—

'I find that a broom results from a prolific development of small twigs on one or a few knotty, swollen parts of a branch. Each central knot we may regard as the position of the bud which was first infected, and from which the broom system took its origin. As one result of the attack of the fungus, the greater number of the buds in the axils of the scales of the infected bud have grown out as twigs, but not into well-

developed ones. In consequence, nearly every twig has been killed back by the winter, but not completely, so that from each twig-base has sprung a new crop of stunted, immature twigs like the first, and equally liable to be killed in the following winter. Thus has arisen that tangled mass of dead or sickly birch twigs which we call a witches' broom.'

At one time these brooms were very well developed on a

FIG. 34.—Witches' brooms of birch, produced by *Exoascus turgidus*. Reduced.

birch-tree in Kew Gardens. One of the brooms measured two yards in diameter, and when removed was found to contain seven nests, belonging respectively to blackbirds and thrushes. On this broom some of the more elongated branches bore clusters of buds forming miniature brooms, caused by the mite *Eriophyes rudis*.

Unless considered ornamental, the brooms should be

removed. It is perfectly certain that a tree bearing a considerable number of large brooms continues to flourish just the same as if such structures were absent.

Cherry leaf blister, caused by *Exoascus minor* (Sadeb.). Diseased leaves become slightly thicker in substance, change

FIG. 35.—*Exoascus alni-incanae*, causing enlarged scales of alder catkins.

to a pink or red colour, and are more or less curled up. The surface is covered with a delicate white bloom when the spores are produced. Diseased leaves soon die and decay. The mycelium hibernates in the buds.

As the mycelium is perennial in the living plant, pruning all diseased shoots is the only remedy.

Exoascus alni-incanae (Kühn) causes enlargement of the scales of alder catkins. The much enlarged scales project from the catkins as reddish, fleshy, irregular outgrowths, which become whitish at a later stage, due to the presence of numerous asci.

Exoascus carpini (Rostr.) forms dense witches' brooms on hornbeam. The branches are thickened, stunted, and much branched; leaves crowded, somewhat curled, and bear the asci on their under surface.

Exoascus Johansonii (Sadeb.) caused deformation of the carpels of poplar catkins, which assume a golden yellow colour. *Populus tremula* and other species are attacked.

TAPHRINA (Fries.)

Forming more or less pronounced convex blisters on living leaves. Asci produced on the concave surface of the

FIG. 36.—*Taphrina bullata.* 1, leaf of pear-tree with blisters caused by the fungus, reduced; 2, asci on epidermis of a leaf, highly mag.

blisters, which are on the under surface of the leaves. Mycelium not perennial in the tissues.

The species are not as a rule injurious to any marked extent.

Taphrina aurea (Sadeb.) forms large blisters on leaves of the black poplar. The blisters are quite prominent, and become bright golden-yellow on the concave side, due to the presence of innumerable asci containing yellow spores.

Taphrina Sadebeckii (Johans.) produces slightly elevated blisters of a white or yellowish colour, on the under or, less rarely, the upper, surface of alder leaves.

Taphrina bullata (Tul.) forms convex, thickish blisters on pear leaves. The blisters are green at first, then become brown and covered with whitish asci on the under surface. Quince leaves are also sometimes attacked.

Taphrina ulmi (Johans.) forms blisters on leaves of the common elm and the wych elm. The blisters are at first green, then dull brown. Asci appear on the under surface of the leaf.

Various other species of *Exoascus* and *Taphrina* occur in Britain, but are of no economic importance.

Atkinson, 'Leaf-curl and Plum-pockets,' *Cornell Univ. Agric. Exp. Station, Bull.* No. 73 (1894).

Rostrup, *Taphrinaceae Danicae* (1890).

Sadebeck, *Die Parasitischen Exoasceen* (1893).

Sadebeck, *Ber. d. deutsch. Bot. Ges.* (1895).

Tubeuf and Smith, *Diseases of Plants* (Engl. ed.) 1897.

Ward, *Diseases of Plants*, p. 107.

PERISPORIACEAE

The members of this family come under the popular designation of mildews, the species commonly occurring in this country forming the well-known white patches on leaves of hops, peas, vine, etc. The mycelium is entirely superficial, and sends haustoria into the epidermal cells of the host-plant. In the genus *Phyllactinia*, however, certain hyphae enter through the stomata into the intercellular spaces of the leaf, and send haustoria into the cells. One group, most abundant in tropical countries, has black mycelium, which forms a thick film on the surface of living leaves and fruit. These black species are not such destructive parasites as the white forms are, but depend on the presence of 'honey-dew,' deposited on the leaves by insects. The family is divided into two groups, as follows :—

Mycelium white at first, in some species becoming brown with age. Spores hyaline, continuous. *Erysipheae*.

Mycelium black. Spores coloured or hyaline, continuous or variously septate. *Perisporieae*.

Salmon, E. S., 'A Monograph of the Erysiphaceae,' *Mem. Torrey Bot. Club*. New York.

PODOSPHAERA (Kunze)

Perithecia with the appendages springing from the apex, or the equatorial region, tips of appendages forked, ascus solitary, 8-spored.

Distinguished from *Sphaerotheca*, the only other genus having only one ascus in the perithecium, by the appendages not originating from the base of the ascus.

Powdery mildew of the cherry (*Podosphaera oxyacanthae*, De Bary) often proves very injurious not only to the foliage of the cherry, but also to that of the apple, peach, quince, and various other cultivated and wild plants belonging to Rosaceae. It first appears under the form of small, scattered, whitish patches on both surfaces of the leaf, these patches gradually extend until the greater part, or the whole, of the leaf is covered. It also attacks the young shoots. As a rule perithecia are sparingly produced, and on some hosts where the conidial form is abundant, the winter fruit has never been observed. It is suspected that the mycelium hibernates during the winter on the host.

Mycelium persistent or almost disappearing, perithecia subglobose, appendages very variable in number and in length, springing from the equator or nearer the apex of the perithecium, basal portion brown, apex 2-4 times forked, ultimate branchlets more or less knobbed, ascus pear-shaped, containing 6-8 spores of variable size, $16\text{-}30 \times 10\text{-}20\ \mu$.

But little injury results when full-grown foliage is attacked, but when the leaves are young, and tender shoots are infected, the damage is often very serious, and nursery stock more especially is often killed outright. Bordeaux mixture, commencing with half-strength solution when the leaves are young and soft, will arrest the course of the disease.

Waite, M. B., *Ann. Rep. Dept. Agric. U.S.* (1888).

Podosphaera tridactyla (De Bary) forms a white mildew on cultivated plum leaves, it also infests other wild and cultivated species of *Prunus*, etc.

Perithecia subglobose, having a tuft of appendages growing nearly erect from its apical portion, tips of appendages 3-5 times forked, tips of ultimate branchlets knobbed. The solitary subglobose ascus contains 8 spores, averaging $20\text{-}30 \times 12\text{-}15\ \mu$.

Salmon considers this species to be a variety of *P. oxyacanthae*.

SPHAEROTHECA (Lév.)

Perithecia having the vague, floccose appendages springing from its base and interwoven with the mycelium; ascus solitary, 8-spored.

American gooseberry mildew (*Sphaerotheca mors-uvae*, Berk.) has long been known as a serious pest in the United States, its destructiveness being so pronounced that in many districts the cultivation of gooseberry bushes has been discarded, and this is more especially true of the introduced European varieties. It also occurs on wild varieties of gooseberry in the United States. I recorded the first appearance of this pest in Europe, in the *Gardeners' Chronicle*, Aug. 25, 1900, fig. 39. The specimens were sent to Kew for determination by Mr. F. W. Moore, F.L.S., Keeper of the Royal Botanic Gardens, Glasnevin, Dublin, and came from the county Antrim. It is assumed that the disease was in some way imported to Europe from the United States, but there is no direct evidence on this point. Since the above date the disease has spread rapidly in Ireland, and at the present day it is rampant in several districts in England, and also in most of the countries of northern Europe.

In this country the disease usually appears about the end of May, on the expanding leaf-buds and leaves, and rapidly passes on to the young fruit and shoots. The fungus first appears as a very delicate cobweb-like film, which gradually becomes more compact, of a pure white, and soon becomes mealy owing to the presence of numerous conidia, which arise from the creeping mycelium as upright chains. This is the summer form of fruit, and is produced in abundance throughout the season. It is this summer fruit that enables the disease to spread with such rapidity. The conidia are

dispersed by wind, rain, insects, birds, etc., and each one that alights on a young, growing part of a gooseberry bush is capable of infecting the plant, and starting a new centre of disease. This mode of infection may continue until late in the autumn, under favourable weather conditions, or

FIG. 37.—*Sphaerotheca mors-uvae.* 1, showing mildew on leaf and fruit; 2, winter stage on a shoot; 3, perithecium or winter fruit; 4, ascus containing spores; 5, a chain of conidia or summer fruit; 6, conidia showing fibrosin bodies in their interior; 7, a branch that has been injured by aphides (green fly) at the tip. The recurved spines and brown colour are characteristic. Figs. 1, 2, and 7, nat. size; remainder highly mag.

when an autumnal expansion of buds follows early pruning. As the season advances the white mildew, which at first resembles in general appearance the well-known hop mildew, and rose mildew, becomes denser in substance, more especially on the fruit and shoots, changes to a dingy brown colour, and becomes studded with the dark-brown perithecia or

winter-fruits, which are more or less embedded in the felt of mycelium, which can be removed as a film from its support. During the autumn considerable numbers of the perithecia or winter-fruit fall to the ground, and constitute a source of danger the following season. On the other hand the dusky brown mycelium, with many perithecia, remains on the shoots until the following season, when the ascospores germinate and infect the young leaves and fruit. In many instances when a shoot appears to be perfectly free from disease, a careful examination reveals the presence of minute portions of mycelium located between the buds and the shoot, and I suspect that this mycelium lurking in the axils of the buds plays the part of resting mycelium, and gives origin to the disease the following season, but I have no direct evidence on this point. Resting mycelium of this nature is stated to start the apple-tree mildew, an allied fungus. The European gooseberry mildew (*Microsphaera grossulariae*) is also very common on gooseberry leaves, rarely passing on to the fruit, and in the white conidial condition closely resembles that of the American mildew in its young, white stage, and it is only by carefully conducted microscopic work that the two can be accurately distinguished. In the conidia of the American mildew, certain discoid, cone-shaped, or rod-shaped bodies are present (see fig. of conidia), whereas in the conidia of the European mildew no such bodies are present. The widely different tips of the appendages of the perithecia at once distinguish between the winter fruit of the two species (see figs.).

The bulk of English literature dealing with the subject of American gooseberry mildew is perhaps more interesting from a psychological than from a pathological standpoint.

Mycelium persistent, forming compact, felty wefts, changing from white to a dingy brown colour; perithecia gregarious, partly immersed in the weft of mycelium, appendages usually few, coloured, short, and usually crooked; ascus subglobose, spores, $20\text{-}25 \times 12\text{-}15\ \mu$.

As no part of the mycelium of the fungus persists throughout the winter in the tissues of the gooseberry plant, it is evident that the appearance of the disease in the spring depends entirely on infection from some outside source. The bulk of such infection results from the presence of winter-fruit that remains on the shoots throughout the winter. In this country, excepting the fruit, the mildew is mainly con-

fined to the tips of the shoots of the year. The bark of older branches cannot be infected. As already stated, many winter-fruits fall to the ground during the autumn, these remain lying on the ground, germinate the following spring, and infect the bushes.. The above condition of things suggests pruning early in the autumn. All prunings should be placed at once in some receptacle and burned, and not thrown on the ground. During a late, mild autumn there is the chance of new growth appearing as the result of early pruning, and it is most important that such young growth should not become infected, although the risk is not great, as I have never once seen winter-fruit produced on mycelium developed late in the autumn. To prevent the risk of autumn infection the bushes should be sprayed with potassium sulphide immediately after pruning, and again at a later date if new growth appears. If the ground is turned over during the winter, fallen winter-fruit will be buried. Not later than the middle of January thoroughly drench all bushes that have been diseased with the following solution: 2 lb. sulphate of copper, $\frac{1}{2}$ lb. of good quicklime, and thirty gallons of water; this is prepared after the manner of Bordeaux mixture. This treatment must be applied before the buds begin to swell, otherwise the foliage will be injured.

In the spring when the leaf-buds begin to open, spray with a solution of potassium sulphide (liver of sulphur), 1 lb. in forty-eight gallons of water; afterwards when the leaves are expanded increase the strength of the solution to 1 lb. in thirty-two gallons of water. From the middle of May to the end of June is a critical time, as the winter-spores germinate about this time, and start the infection for the season, hence if the mildew is kept well in hand at the start an epidemic is prevented.

American gooseberry mildew has also been found on red-currant bushes, and it may possibly also pass on to black-currants and raspberries.

A more detailed account of preventive methods is given in the leaflet entitled, *American Gooseberry Mildew*, which can be procured free of cost on application to the Secretary, Board of Agriculture and Fisheries, 8 Whitehall Place, London, S.W.

Eriksson, *Journ. R. Hort. Soc.*, 34, p. 469 (1909).
Salmon, *Report on Economic Mycology, Wye College* (1908).

Rose mildew.—This scourge of the rosarian is the work of *Sphaerotheca pannosa* (Lév.), it is also abundant on wild roses. It attacks the leaves, young shoots, and flower-buds. On the leaves it forms a very delicate white mildew, which in course of time becomes mealy from the presence of conidia. On the shoots, calyx, and fruit the mycelium on the other hand forms thick, felty patches of a dingy white colour, that persist till late in the season. Perithecia do not appear to be formed on the sparse mycelium present on the leaves, but occur on the felted mycelium present on the shoots and fruit, where they are quite immersed in the felt, and are not very conspicuous. It is to be noted that the conidial form of reproduction is very scantily produced on the felted type of mycelium, suggesting a kind of differentiation in function between the thin, evanescent mycelium present on the foliage, and the felted kind met with on the shoots, calyx, and fruit. The former is most concerned in producing conidia, which serve for the extension of the species in space, whereas the felted mycelium bears the ascigerous or winter form of fruit, whose function is to continue the species in time, or to secure its continuance from year to year.

As a rule during ordinary seasons there are two distinct waves of disease during the year. The first, which is generally slight, occurs soon after the leaves are fully expanded. The second wave occurs after midsummer, when the young wood has made considerable growth, and the flowers have begun to appear. This is the critical period, for, as already stated, the ascigerous fruit, which alone can perpetuate the disease the following season, is produced on the young wood and fruit. The spring wave of disease, although it may injure the individual plant, cannot perpetuate the disease, as the mildew is at that stage confined to the foliage, and does not produce winter fruit.

Diseased leaves curl and fall after producing chains of conidia only. Perithecia are produced on the felted mycelium present on the young wood and fruit, appendages short, colourless, ascus solitary, subglobose containing eight elliptical spores, $20\text{-}27 \times 12\text{-}15\ \mu$.

Dusting with flowers-of-sulphur, mixed one-third its volume of quicklime, checks the disease, as also does spraying with sulphide of potassium. I find, however, that spraying with sulphuric acid—one part in 1500 parts of water—is a very certain cure, both under glass and in the open. It is very

important that the spring wave of disease, which is apt to be neglected on account of the small quantity present, be thoroughly stamped out, otherwise it lingers in small quantity, and starts the more serious summer wave of disease.

Massee, *The Enemies of the Rose*, National Rose Soc. (1908).

Strawberry mildew.—This disease, caused by *Sphaerotheca humuli* (Burr.), has long been known as destructive to strawberries. Berkeley records an instance of a crop of strawberries having been completely destroyed by this fungus in 1854. Both foliage and fruit are attacked, but in many instances the leaves alone suffer; there are no conspicuous blotches or spots present on the upper surface of the leaves, but the certain indication of the presence of the parasite is the gradual turning upwards of the edge of the leaf, until nearly the whole of the under surface is exposed, which, if examined with a pocket-lens, is seen to be covered with a delicate whitish down—the conidial condition of the fungus. This often occurs rather late in the season, after the fruit has been gathered, when almost every leaf in a field presents the strongly turned up appearance. The greatest amount of damage is done when the leaves are attacked early in the season, during the flowering stage, as not infrequently the fungus passes on to the ripening fruit, which is totally destroyed. I have seen a heavy crop of fruit so completely covered with the conidial form of the fungus, that the berries presented the appearance of having been thickly dredged with flour. I once saw large quantities of strawberries presenting a very dull, water-logged appearance exposed for sale in the market at Yarmouth, and on investigating the matter, learned that the fruit was covered with white powder, the fungus under consideration, which had been more or less removed by shaking the fruit in water. The experiment was not a success, as what little sweetness and flavour was left by the fungus had been removed by the water. The perithecia or winter-fruit, which alone are responsible for the appearance of the fungus each season, has not, so far as I am aware, been met with on the strawberry in this country, although they have been reported from the United States, where the fungus is equally common and destructive as with us. Notwithstanding the absence of winter-fruit on strawberry plants, when it is remem-

bered that *Sphaerotheca humuli*, the notorious 'hop mildew, occurs abundantly also on about twenty British weeds, it is not difficult to understand the infection of strawberry plants by winter-fruit produced on one or other of these hosts.

The conidia are, as usual in the genus, produced in chains, and when mature are elliptical, 30-40 × 17-24 μ. Perithecia minute, dark coloured, with numerous short, brownish appendages mixed up with the mycelium. Asci from subglobose to broadly ovate, containing up to eight spores, broadly elliptic, hyaline, 15-20 × 12-15 μ.

It is important that constant watch for the first appearance of the fungus on the leaves should be kept, and prompt spraying with sulphide of potassium should follow. By such means the disease can be arrested before the fungus attacks the fruit. When the disease is general on the foliage, the wisest course to pursue in the late autumn, when the leaves are beginning to fade, is to strew the flat with loose straw or litter of any kind that will burn readily, and fire it. By so doing, all the leaves are destroyed, and although winter-fruit has not actually been found, this does not prove that such do not exist, and should such be the case, they would be destroyed.

The ground should be kept clear of weeds that harbour the fungus; among such may be enumerated, wild hops, willow-herb, meadowsweet, etc.

Hop mildew (*Sphaerotheca humuli*, Burr. = *Sphaerotheca castagnei*, Lév.) is the cause of serious losses to cultivators of hops, both in this and other countries. The mildew commences as small, delicate white patches on the leaf, most abundant on the under surface perhaps. These patches gradually increase in size, until, under favourable climatic conditions, the entire leaf is covered with mildew, which soon presents a mealy appearance, due to the formation of immense numbers of conidia. So long as the mildew is confined to the foliage the injury is not so grave, but when it passes on to the female cones the damage becomes serious.

Mycelium often disappearing, sometimes persistent, perithecia variable in size, blackish, appendages very variable in size and length, usually brown, often eight or nine times as long as diameter of perithecium, the solitary ascus contains eight spores of an elliptical form, averaging 22 × 15 μ.

The fungus is common on many wild plants, as meadowsweet, yarrow, willow-herbs, geraniums, agrimony, etc.; all such should be kept away from the vicinity of hop fields.

Sulphur in some form has proved to be the best fungicide. Flowers-of-sulphur should be dredged on the plants during sunshine, as then fumes are given off. Sulphide of

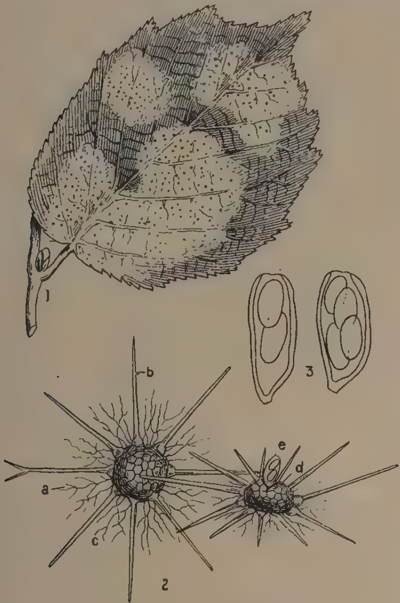

FIG. 38.—*Phyllactinia suffulta*. 1, hazel leaf with patches of mildew; 2, perithecia, *a*, appendages; *b*, mycelium; *c*, ascus escaping from a perithecium *e*; 3, asci containing spores. Fig. 1 somewhat reduced; remainder highly mag.

potassium in solution should also answer, if spraying is commenced sufficiently early in the season.

PHYLLACTINIA (LÉV.)

Perithecia depressed, appendages straight, sharp pointed, with a bulbous base; asci many, rarely 3-4 spored.

Readily recognised by the needle-shaped appendages springing from a large bulbous or swollen base.

Hazel leaf mildew.—During certain seasons there is quite an epidemic of mildew on hazel leaves, which become more or less completely covered on the under surface with a delicate white mildew called *Phyllactinia suffulta* (Sacc.) When this happens the leaves fall early in the season. I once saw the hazel undergrowth of an extensive wood in Yorkshire almost completely defoliated in July, due to an attack of this fungus. I have also seen the fungus growing on the young green nuts. Curiously enough although perithecia or winter fruit are usually produced in abundance, the disease may not appear again for years after a severe attack. The fungus also attacks the foliage of many other trees and shrubs.

Perithecia scattered, hemispherical then depressed, comparatively large; asci 4-20, ovate, shortly pedicellate, 2, rarely 3-4-spored; spores elliptical, size variable, $40\text{-}52 \times 22\text{-}25\ \mu$.

I am not aware that any attempt has been made to combat this disease, which appears to do but little injury to cultivated plants. In all probability potassium sulphide solution would answer, as in the case of allied pests.

UNCINULA (Lév.)

Perithecia with simple, rarely forked appendages, curled at the tip. Asci several, 2-8-spored.

Distinguished by the simple appendages being curled at the tip.

Powdery mildew of the vine.—This destructive disease of the vine was first detected in Europe in a vinery at Margate, and as the conidial form of the fungus was alone met with it was named *Oidium Tuckeri* by Berkeley. This was in the year 1845, and within ten years it had spread throughout the entire grape-producing countries in Europe, Syria, Asia Minor and Algeria. The wholesale destruction caused by this parasite proved ruinous to numerous cultivators, and led to the abolition of many vineyards in different countries. For many years the conidial condition was alone found in Europe, in fact it was not until 1892

that the ascigerous fruit was first met with on grapes, both growing under glass and out of doors. This discovery

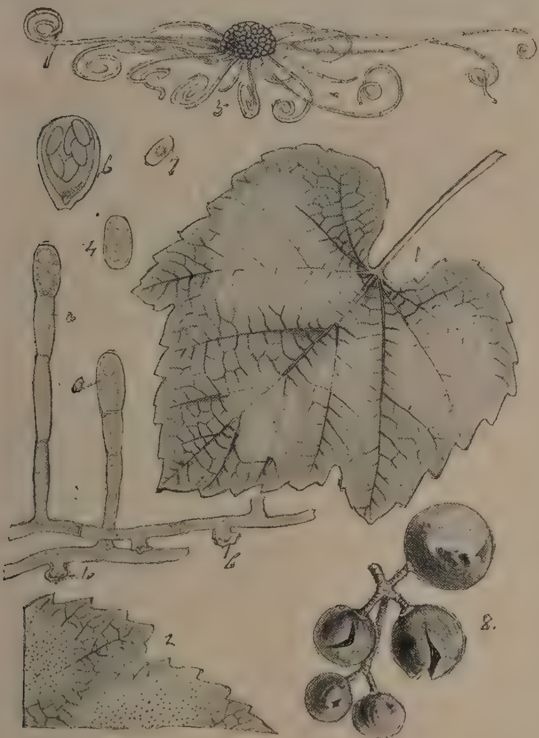

FIG. 39.—*Uncinula spiralis.* 1, fungus forming white mildew-patches on upper surface of vine leaf; 2, portion of vine leaf with fungus bearing perithecia; 3, mycelium bearing erect chains of conidia, *a*, *a*, and haustoria which enter the cells and absorb food, *b*, *b*; 4, a single conidium; 5, a perithecium with its curled appendages; 6, an ascus containing six spores; 7, a free ascospore; 8, grapes attacked by the fungus. Figs. 1 and 2 somewhat reduced; the rest highly mag.

showed the fungus to be *Uncinula spiralis*, Berk. and Curt. (= *Uncinula necator*, Burr.). This fungus is undoubtedly of

exotic origin, but how or from where it was introduced into Europe is by no means certain, as it occurs on native plants both in the United States and in Japan. The mycelium of the fungus forms white or greyish patches on the upper surface of the leaves, young shoots, inflorescence, and fruit. These patches, which are small at first, gradually extend until the entire surface of the organ attacked becomes covered with a white mildew. After a time numerous upright chains of white conidia are formed, and as these chains collapse, the surface of the mycelium becomes covered with a powdery mass of conidia, as if it had been dusted with flour, hence the name powdery mildew. These conidia are dispersed by wind, rain, etc., and consequently the epidemic continues to spread throughout the season unless stringent preventive measures are resorted to. The injury caused by the fungus is due to its haustoria or food-absorbing organs entering and killing the epidermal cells of the host. The effect produced depends on the organ attacked. When young leaves are attacked their further growth becomes irregular, and they usually shrivel and die; in the case of older leaves the mildew may cause but little injury, merely causing brown spots to appear on the portions attacked. When young shoots are infected, the upper portion usually blackens and dies, whereas when older branches become diseased, the presence of brownish stains afterwards indicates the portions occupied by the parasite. When the flowers are attacked no fruit is formed, and when the fruit is attacked it usually cracks and becomes useless. When the seasonal vigour of the host is on the wane the ascigerous form of fruit appears on the mycelium, under the form of minute, rounded bodies, at first yellow, gradually changing to dark brown. These fruits or perithecia contain the winter spores, and are furnished with several radiating appendages, each one hooked at the tip.

Ascigerous form. Mycelium occurring on both sides of the leaf, sometimes almost disappearing; perithecia minute, scattered, globose, depressed, blackish, furnished with a variable number of straight, or slightly-wavy appendages, curled at the tip, the lower half brownish. Asci varying in number from 4-9, spores 4-7 in an ascus, elliptical, ends rounded, 18-25 $\times$ 10-12 μ.

Conidial form. Chains of hyaline elliptic-oblong conidia.

Professor Galloway states: 'It succumbs readily to sulphur,

either in the form of flowers-of-sulphur, or solutions of the sulphide. In applying the sulphur, bellows should be used, and the applications should be made ten or twelve days before the flowers open, the second when in full bloom, and a third three weeks or a month later, if the disease seems to be on the increase. The best results are obtained when the thermometer is ranging between 80° to 100° F. In this temperature fumes are given off which quickly destroy the fungus. We have obtained excellent results in treating this disease with a solution made by dissolving half an ounce of potassium sulphide to the gallon of water. The preparation is cheap, and can be quickly and effectively applied with any of the well-known spraying pumps. The greatest care should be exercised in making the second spraying, which, by the way, should be at the same time as that mentioned for the flowers-of-sulphur, in order to protect the blossoms from the fungus.'

The common practice of placing sulphur on hot pipes is a very risky one and should not be followed.

Berkeley, *Gard. Chron.*, Nov. 27 (1847).
Prillieux, *Malad. des Pl. Agric.*, 1, p. 17 (1897).
Scribner, *U.S. Dept. Agric.*, *Bull.* No. 11.
Viala, *Les Malad. de la Vigne*, p. 32.

Uncinula mori (Miyake) is described as a pest attacking mulberry leaves in Japan, where it is known as 'Omoteshirshibubyo,' or upper-side mildew, as it occurs mostly on the upper side of the leaves. Perithecia, small, black, 92-130 μ diam., appendages 12-26 in number, usually 15-17, 130-216 μ long, basal portion thick-walled, above thinner, and the outline nodulose or slightly crumpled, with a small close half-turn at the tip. Asci 4, rarely 6, $50\text{-}60 \times 40\text{-}50\ \mu$. Spores 4-5 in an ascus, elliptical, $27\text{-}35 \times 14\text{-}19\ \mu$.

Miyake, I., *Bot. Mag.* (Japan), 21, p. 1 (1907).

MICROSPHAERA (Lév.)

Perithecia containing several 4-8-spored asci; appendages repeatedly forked at the tip.

Gooseberry-leaf mildew (*Microsphaera grossulariae*, Lév.)

is somewhat erratic in its appearance, and during certain seasons it covers both surfaces of the leaves of gooseberries with a delicate greyish-white mildew. Less frequently the fruit is also attacked. When the mycelium is well established on the leaf, it becomes covered with a mass of conidia, giving to it a mealy appearance. The ascigerous condition is usually produced in abundance later in the

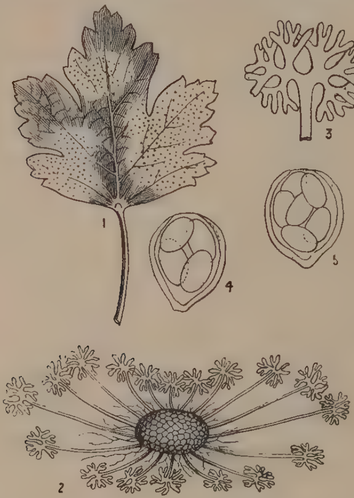

FIG. 40.—*Microsphaera grossulariae.* 1, gooseberry leaf with patches of mildew; 2, a perithecium with its appendages; 3, tip of an appendage; 4 and 5, asci containing spores. Fig. 1 nat. size; the remainder highly mag.

season, and is readily recognised under the microscope by the elaborate tips of the appendages.

Mycelium delicate, greyish-white on both surfaces of the leaf; perithecia usually in small, scattered groups, dark brown, appendages once or twice as long as diameter of peridium, 4-6 times forked at the tip; asci 3-10, ovate, containing 3-6 spores of variable size, $20\text{-}30 \times 12\text{-}15\ \mu$.

As a rule this parasite cannot be considered as injurious. Spraying with potassium sulphide is effective if commenced when the leaves are unfolding.

Microsphaera lonicerae, Wint. (= *M. alni*, var. *lonicerae*, Salm.) forms white mildew on the leaves of honeysuckle, but does no appreciable injury.

Perithecia globoso-depressed, blackish, appendages once to twice as long as diameter of perithecium, 3-4 times forked at the tip; asci 2-7; spores 3-6, $20\text{-}24 \times 10\text{-}12\ \mu$.

Microsphaera berberidis (Lév.) forms white patches of mildew on the leaves of barberry and *Mahonia*.

Perithecia generally scattered, appendages having the tips four times forked, branchlets straight; asci 4-9; spores 4-6 in an ascus, $18\text{-}20 \times 9\text{-}10\ \mu$.

ERYSIPHE (D. C.)

Perithecia subglobose, appendages, simple or irregularly branched, closely resembling the mycelium. Asci several, 2-8-spored.

Recognised by the simple or vaguely branched appendages, which much resemble the mycelium, with which they are intermixed.

Erysiphe polygoni (D. C.) forms a white mildew on the leaves of cultivated peas, turnips, etc., and on various wild plants.

Mycelium variable in quantity, sometimes only forming a thin film, at others dense; perithecia gregarious or crowded, small, appendages very variable, coloured, irregularly branched; asci variable in number, size, and shape, containing a variable number of spores, usually 3-6, $19\text{-}25 \times 9\text{-}14\ \mu$.

Mildew on oak.—As a rule the oidium occurring on oak leaves is rare, and for many years in succession is entirely absent, but during 1908 there was a serious epidemic both in this country and on the Continent, not only the vigorous shoots from stools, the parts most usually attacked, but also the leaves on the younger branches of old trees. Not a single ascigerous fruit was observed anywhere, hence the species to which the oidium stage belongs is uncertain.

THIELAVIA (Zopf)

Perithecia globose, minute, asci many, ovate, 8-spored; spores elliptical, continuous, coloured.

Two or three conidial conditions known = *Torula basicola* (Berk.); *Milowia nivea* (Mass.), etc.

Black root rot (*Thielavia basicola*, Zopf) was first met with in England on the roots of peas, and called *Torula basicola* by Berkeley and Broome. Four kinds of fruit have been described, the highest of which is an ascigerous form discovered in Germany by Zopf, on the root of a *Senecio*. Some doubt was at one time entertained as to whether the

FIG. 41.—*Thielavia basicola*. 1, diseased pea root; 2, portion of first conidial stage (*Milowia*); 2 ×, free conidia of same; 3, second conidial stage (*Torula*); 3 ×, a conidium of same breaking up into cells; 4, ascospores; 5, perithecium on winter fruit; 6, ascus containing 8 spores, from winter fruit. Fig. 1 nat. size; remainder highly mag.

fungus was a true parasite, and although capable of existing on manure and dead plants as a saprophyte, recent observations and experiments have proved that under certain conditions, more especially on badly drained or water-logged soil, the fungus acts as a very destructive parasite.

The fungus has been found parasitic on numerous different kinds of plants belonging to widely separated families, as

peas, begonias, tobacco, lupines, groundsel, violets, etc. It is perhaps most partial to members of the Leguminosae.

The root is the part attacked, and the yellowing and wilting of the foliage, and the eventual death of an infected plant is often attributed to other than the true cause, which can only be determined when an examination of the root is made.

The mycelium permeates the tissues of the root, and is very delicate and colourless when produced in the tissues, but becomes tinted when developed on the surface of the root, and it is here that the various forms of spore are produced. The first kind to appear are known as endospores, functionally summer spores. These are produced in chains within a mother-cell or hypha, from the ruptured extremity of which they are pushed out by the formation of new spores at the base of the chain within the parent hypha. These endospores germinate as soon as liberated, and probably spread the disease rapidly. The endospores and their mycelium form a delicate, almost colourless mould surrounding the root and are apt to be overlooked. At a later stage, the same mycelium that bore endospores, gives origin to a second form of fruit known as chlamydospores. These are comparatively large, club-shaped, dark brown, many-septate spores, borne singly or in clusters on the colourless mycelium surrounding the root. These spores are produced in great abundance, and give to the root a blackened or charred appearance. Chlamydospores do not germinate until after a period of rest, and serve to tide the fungus over that period of the year when its host-plant is not forthcoming. The chlamydospore condition was the only one seen by Berkeley and Broome. At a yet later stage, when the plant is dead, the highest form of fruit, consisting of ascospores produced in a closed perithecium, are formed.

In this country peas are most frequently attacked, but the parasite has also been recorded on other plants. In Italy, and more especially in the United States, the tobacco crop has suffered severely.

Endospores produced in chains and escaping from a sheath, hyaline, $12\text{-}28 \times 4\text{-}5\ \mu$. Chlamydospores narrowly club-shaped, dark brown, many-celled, septa thick, eventually breaking up into their component cells, $30\text{-}65 \times 9\text{-}16\ \mu$. Perithecia globose, black; asci 8-spored, spores lenticular, coloured, $12 \times 5\ \mu$. Zopf also mentions the presence of pycnidia containing minute stylospores or spermatia.

Notwithstanding the serious injury caused by the fungus in seed beds and fields, but little is known respecting preventive measures. It is proved that the fungus is most aggressive in soil containing stagnant water, which suggests the necessity of better drainage. Professor Clinton recommends sterilising the soil of seed beds with a pint of commercial formalin mixed with twelve and a half gallons of water, using two-thirds of a gallon to each square foot. The soil should be covered with sacking for two days to keep in the fumes of the formalin. Commercial fertilisers may be applied either before or after the bed is treated, but manure should be used before treatment, so that it may be sterilised. A week at least should elapse after treatment before the sowing or planting is commenced.

Berkeley and Broome, *Ann. Mag. Nat. Hist.*, Ser. 2, v. p. 461 (1850).

Zopf, *Sitz. Bot. Ver. Prov. Brandenburg*, 18, p. 101 (1876).

Zopf, *Zeit. Pflanzenkrankh.*, 1, p. 72 (1891).

Clinton, *Connecticut State Agric. Exp. Sta. Rep.*, 1906, p. 342.

DIMEROSPORIUM (Fckl.)

Perithecia depressed, membranaceo-carbonaceous; asci subglobose, 8-spored; spores 1-septate, hyaline or brownish; mycelium abundant, black, forming a film, often bearing conidia.

Mango black blight (*Dimerosporium mangiferum*, Sacc. = *Capnodium mangiferum*, Cooke and Broome) forms intensely black, velvety patches on both surfaces of the leaves of the mango (*Mangifera indica*). The fungus commences as little black points which extend rapidly and encroach on each other, so that eventually the greater portion, or even the whole of the leaf surface, is covered with a dense weft of mycelium. This felt is generally easily rubbed off by the fingers, and does not enter into the tissues of the leaf, nevertheless it is very injurious, as its presence prevents the leaf from performing its normal functions. It is suspected that the present fungus, like many of its black, film-forming allies, is favoured by the presence of 'honey-dew' on the leaves, deposited by aphides, etc. Under the circumstances the

aphides should be kept in check. Resin wash is the best-known remedy for the sooty moulds.

Often covering the entire surface of the leaf with a black, velvety felt; perithecia narrowly ovate, elongated, asci pear-shaped, $48\text{-}50 \times 30\ \mu$, 8-spored; spores hyaline, 1-septate, elliptical, slightly constricted at the septum, $12\text{-}15 \times 5\text{-}6\ \mu$.

MELIOLA (Fries.)

Perithecia seated on black, radiating mycelium, globose, often furnished with specialised appendages; asci subglobose,

FIG. 42.—*Meliola Penzigii.* Sooty mould of orange and citron, on orange leaves. Nat. size.

2-8-spored; spores 2-5-septate, sometimes muriform, hyaline or coloured.

Sooty mould of orange.—This disease is more or less prevalent wherever the orange is cultivated. In Europe and the United States the injury is usually attributed to *Meliola*

Penzigii (Sacc.) and *M. camelliae* (Sacc.), but probably other species, or even members of other genera, form similar sooty films on the leaves and fruit of living plants in different countries. M'Alpine has shown that the sooty patches occurring on fruit and leaves in Australia are distinct species. On the leaves and fruit of the orange, citrus, and lemon, these fungi form a compact black membrane, which frequently cracks and peels off in flakes during dry weather, leaving the surface upon which it rested quite clean and apparently uninjured, although at the same time much injury is caused by preventing leaves from performing their functions, whereas when the fruit is more or less covered by the fungus it is rendered unsaleable. These fungi are not parasites in the sense of obtaining food from the host through mycelium permeating the living tissues, but assimilate 'honey-dew' deposited on the leaves by aphides or species of green-fly, etc., consequently if trees are kept free from these insect pests, sooty mould would not be present.

M. Penzigii.—Mycelium forming a black crust which readily peels off; perithecia seated on the mycelium, subglobose, black, 150-160 μ diam. Asci pear-shaped, 8-spored; spores ovate-oblong, 3-septate, with one or more vertical septa, hyaline then tinged brown, $11\text{-}12 \times 4\text{-}5\ \mu$. Several secondary or conidial forms of fruit have been described.

M. camelliae. On leaves of camellias.

Swingle and Webber, who have paid much attention to the subject, have come to the conclusion that 'resin-wash' is the most effective remedy for destroying the various kinds of insects that secrete 'honey-dew.' Spraying should be done when the insect is in the larval or pupal condition, and as this period differs in time in different countries, careful observation should be kept.

Fumigation with hydrocyanic gas has also proved effective, and trees should be exposed to the fumes for about forty-five minutes, and should be done when the temperature is low. It has also been pointed out by Webber that the species of fungi belonging to a genus called *Aschersonia* are parasitic on the insects producing honey-dew, and are often present in large numbers, and he considers that these fungi might be introduced and fostered, as a means of keeping the insects in check. Many attempts have been undertaken to utilise parasitic fungi as a check to the ravages of various insects, but unfortunately without much success so far; nevertheless

it is very important that where such fungi do exist, they should be recognised and preserved and not destroyed as most fungi present on living parts of plants are, or ought to be. I have shown elsewhere that species of *Aschersonia*, which hitherto were only known to produce a conidial form of reproduction, when parasitic on insects on living leaves, also produce an ascigerous form of fruit, following the conidial stage, when the leaves are dead and fallen. Such dead leaves should be allowed to remain until the ascigerous form of fruit is matured, the spores of which give origin to the conidial stage which attacks the insects present on living leaves.

Massee, *Journ. Bot.*, 34, p. 357 (1896).
Swingle and Webber, *U.S. Dep. Agric.*, *Dep. Veget. and Physiol.*, *Bull.* No. 8.
Webber, l.c., *Bull.* No. 13.

CAPNODIUM (Mont.)

Mycelium effused, black, perithecia simple or branched, cylindrical, mouth narrowed and often torn or fringed; asci elongated; spores 3-4 septate or muriform, coloured.

Willow sooty mould (*Capnodium salicinum*, Mont.) often covers the leaves of willows with a dense black felt consisting of much branched and interwoven hyphae; these are attached to the surface of the leaf by a thin layer of cells with sub-gelatinous walls by which they are glued together into a thin pellicle, which in turn is cemented to the surface of the leaf. At times this membrane breaks away from the leaf and peels off in fragments, carrying along with it the entire film of mycelium. Many different forms of conidial reproduction have been described, but the life-history of this species, in common with that of the allied forms of sooty mould, is by no means well known. Numerous horn-like, simple, or branched conceptacles are produced, which contain conidia of different forms and sizes. The true ascigerous perithecia are more or less cylindrical, apex somewhat thickened, and contain numerous asci, each containing 6-8 spores of a brown colour, 3-septate, the central cells often with one or two vertical septa. The fungus is not a parasite, but feeds on honey-dew deposited on the leaf by insects.

Many other equally ill-defined species form black films on various trees, shrubs, and herbs, as oak, olive, lime, hazel, speedwell, various grasses, etc.

Prillieux, *Malad. des Plantes Agric.*, 2, p. 44 (1879).

Capnodium citricolum (M'Alpine), known as 'black blight' in Australia, where it is widely distributed on the leaves and fruit of oranges and lemons. Like allied forms it is not a parasite, but follows in the wake of honey-dew deposited by insects, hence the remedy consists in preventing the deposition of the honey-dew by using an insecticide.

M'Alpine, *Proc. Linn. Soc. N. S. Wales*, p. 469 (1896).

ASTERULA (Sacc.)

Perithecia seated on black, radiating, subsuperficial mycelium, depressed, almost mouthless; asci generally 8-spored; spores continuous, hyaline.

Asterula beyerinckii, Sacc. (=*Ascospora beyerinckii*, Vuill.), is considered by Vuillemin as the ascigerous condition of *Coryneum beyernickii* (Oud.), but the point has not been definitely determined.

Ascigerous condition. Mycelium plentiful, crustaceous; perithecia globoso-depressed, mouth very minute or absent, 100-130 μ diam., black, carbonaceous, erumpent, asci numerous, up to 40, obovate then cylindrical, 110×20 μ; spores elliptical, continuous, hyaline, $17 \times 5{\cdot}7$ μ.

Conidial form=*Phyllosticta beyerinckii* (Vuill.). Perithecia globose, surrounded by septate hyphae, 150 μ diam., conidia elliptical, hyaline, 6×5 μ, extruded as a viscid tendril.

Vuillemin, *Journ. de Bot.*, 2, p. 255 (1888).

PYRENOMYCETES

The members of the present group are comparatively legion, and occur in every part of the world where higher forms of plant life exist to serve as hosts. The structural characteristic of the family is the perithecium or fruit-case, in which the asci containing the spores are produced. The perithecium varies in form from globose to flask-shaped, and

is furnished with an opening at the apex through which the spores escape. This opening or mouth may be a minute hole at the apex of the perithecium, or it may be prolonged into a beak of variable length in different species. The perithecia are always minute, and may be scattered singly on the host, or aggregated in immense numbers on a stroma, or compact mass of fungus hyphae of variable form. The spores are produced in asci contained in the perithecium. Conidial stages are abundant in this group, and present great variety of form and structure.

There is no recent work in English on the classification of the Pyrenomycetes.

Saccardo, A. P., *Sylloge Fungorum*, etc., 1 and 2.

A. *Spores continuous* (= 1 *celled*), *hyaline* (*sometimes tinged yellow*).

GUIGNARDIA (VIALA and RAVAZ)

Perithecia innate, lenticular, usually with a projecting mouth, membranaceous; asci 8-spored; spores elongated, continuous, hyaline; paraphyses absent.

Black rot of grapes.—Undoubtedly the most destructive fungus parasite with which American viticulturists have to cope. Ever since its introduction into Europe in 1885 along with vines brought from the United States to replace those destroyed by the Phylloxera, it has proved very destructive, more especially in the case of vines growing in the open air. Both conidial and ascigerous forms of reproduction are known, and the characteristics of the disease are so well marked, that it cannot be mistaken for any other form of disease affecting the vine. *Guignardia Bidwellii* (Viala and Ravaz) is the name of the fungus causing all this injury and loss. On the leaves the fungus causes irregularly circular, small, sharply defined, dead spots, these sometimes encroach on each other and form irregularly shaped patches, which in course of time become more or less covered with minute black perithecia, often arranged in concentric lines, on both surfaces of the diseased spot. This condition of the fungus was at one time called *Phoma uvicola* (Berk. and Curt.). Near the succulent green tips of the shoots the spots are usually

elongated, and produce the *Phoma* form of fructification, as on the leaves. The first indication of injury to the fruit consists in the appearance of a small, livid spot on the skin. At this stage the flesh of the grape below the skin is perfectly sound, proving that infection has occurred from without. The livid spot gradually extends, its mycelium passing into the flesh of the berry, which commences to shrivel, and is soon dead. When the berry commences to shrivel, numerous fructifications of the *Phoma* type stud its surface, the spores from which quickly infect adjoining berries, and as a rule the entire bunch is destroyed. Along with the *Phoma*, a second type of perithecium is often present in considerable numbers. These perithecia contain myriads of very minute, rod-shaped, hyaline spermatia about $5 \times 0{\cdot}5\ \mu$. These bodies have not been seen to germinate, and probably represent the spermogonia and spermatia met with in many other kinds of fungi, and which are supposed to represent the male or fertilising bodies of earlier times when a trichogyne, to which they became attached, was produced by the oogonium or its equivalent. The fact that they just precede the development of the ascigerous fruit supports this view, although they are not considered as of functional value at the present day, but merely survivals During the winter or early spring, those shrivelled and mummified grapes that have been killed by the conidial condition of the fungus, bear a crop of ascigerous fruit, the asci being produced in the same perithecia that previously contained the *Phoma* form of fruit.

Phoma form. Perithecia minute, black, immersed in the matrix, the mouth above protruding and rupturing the epidermis. Conidia broadly elliptical, hyaline, $4\text{-}5 \times 3\text{-}4\ \mu$, sometimes larger, or variable.

Ascigerous form. Asci narrowly obovate, containing eight hyaline, obliquely elliptical spores, continuous, $12\text{-}14 \times 6\text{-}7\ \mu$. Paraphyses absent.

Reddick and Wilson, who have paid much attention to this disease in the United States, recommend the following line of treatment. The first and most important point is to destroy all the old mummified berries, as it is the ascigerous fruit produced on these that commence the disease in the spring. All such should be removed from the vines that have remained hanging, and those lying on the ground should be buried by ploughing or otherwise. Never allow basal shoots to spread out over the ground. Spray thoroughly, first with

Bordeaux mixture, 5-5-50, when the third or fourth leaf is showing; again with the same mixture just when the blossoms are swelling; thirdly, with the same mixture soon after the leaves have fallen. Remaining applications depend on the weather. Use Bordeaux mixture until middle of July, afterwards use ammoniacal copper-carbonate, 5-3-50, which will not discolour the grapes, is nearly as efficient as Bordeaux mixture, and is perfectly harmless to the berries.

Prillieux, *Malad. des Plantes Agric.*, 2, p. 157 (1897).

Reddick and Wilson, *Cornell Univ. Agric. Expt. Sta., Bull.* 253 (1908).

Viala, *Les Malad. de la Vigne*, ed. 3, p. 190.

Cranberry blast and scald.—These diseases are caused by *Guignardia vaccinii* (Shear). The term blast is applied when the flower or very young fruit is attacked, the latter becoming covered with the conidial form of the fungus, which causes it to shrivel at an early age. Scald is applied when the full-grown fruit is attacked. The first indication is the appearance of a minute, light-coloured, watery spot upon its surface. This spreads, usually in a concentric manner, until finally the whole berry becomes soft. Frequently the diseased area is marked by dark-coloured concentric rings. The disease also attacks the leaves sometimes, causing a reddish-brown spot, which eventually bears the conidial or ascigerous form of fruit. The most destructive cranberry disease known in the United States.

Perithecia globose, black, with a slightly prominent mouth. Asci 8-spored, sessile; spores hyaline then yellowish-brown, shortly elliptical or subrhomboid, $13\text{-}16 \times 6\text{-}7\ \mu$. Perithecia of conidia like those of the ascigerous condition; conidia hyaline, obovoid, $10{\cdot}5 \times 13{\cdot}5 \times 5\text{-}6\ \mu$, with a hyaline appendage at the apex.

Five applications of Bordeaux mixture, mixed with resin and fish-oil soap, checked the disease.

Shear, C. L., *U.S. Dept. Agric., Bureau of Plant Industry, Bull.* No. 110 (1907).

Guignardia theae (Bernard) causes spots on living leaves of *Thea assamica*, somewhat resembling those due to *Pestalozzia guepini*.

Perithecia sunk in the substance of the leaf; asci $60 \times 10\text{-}12\ \mu$, without paraphyses; spores $12\text{-}16 \times 5\text{-}6\ \mu$.

Bernard, Ch., *Bull. Dépôt Agric. Ind. Néerland*, No. 6 (1907).

TRICHOSPHAERIA (Fuckel)

Perithecia subglobose, superficial, sparsely or densely hairy, sometimes seated on a byssus; ascia oblong or cylindrical, 8-spored; spores hyaline, continuous, elongated, sometimes appendiculate.

Sugar-cane disease, caused by *Trichosphaeria socchari* (Massee), a wound fungus that gains an entrance into the cane through broken ends of lateral shoots, dead leaf-bases, etc., but more especially through holes made by the moth-borer (*Diatraea saccharalis*, Fabr.) or the shot-borer (*Xyleborus perforans*, Wall.). The mycelium first traverses the vascular bundles, which become bright red, a marked symptom of the presence of the fungus in an early stage of disease. Two conidial forms are produced, which form black streaks on the surface of the cane, the conidia protruding like black, curly hairs from the surface. Finally an ascigerous form appeared on some diseased material at Kew, but this has not been met with elsewhere. The disease was at one time very severe in the West Indies, and has also been recorded from Mauritius, India, Java, and Queensland.

Ascigerous stage. Perithecia broadly ovate, blackish-brown, sparsely clothed with long, dark, rigid hairs; asci cylindrical; spores 8, oblique 1-seriate, continuous, hyaline, elliptic-oblong, $8\text{-}9 \times 4\ \mu$, paraphyses absent.

Only met with on thoroughly decayed, very old canes.

Melanconium stage; oozing out of the surface of dying canes in the form of black, hair-like, curled tendrils; conidia produced in conceptacles in a stroma formed under the epidermis, 1-septate, pale brown, cylindrical, $14\text{-}15 \times 3{\cdot}5\text{-}4\ \mu$.

Macroconidia; forming an intensely black, velvety layer, lining cracks and cavities in decaying canes, conidia in chains originating within the ruptured apex of a hypha, terminal conidium globose, remainder barrel-shaped, blackish-brown, $18\text{-}20 \times 12\ \mu$.

Microconidia; similar in origin and structure to macroconidia, but smaller, growing on the diseased surface of the cane, forming black, velvety patches.

The mycelium spreads rapidly in the cane, and such were at one time used for propagation; this is disastrous, as the disease grows along with the cane. It was also the custom to have diseased canes lying about. This should not be done, as the spores produced on these infect growing canes. Only perfectly healthy canes should be used for propagation.

Massee, *Ann. Bot.*, 7 (1893).
Went, *Ann. Bot.*, 10, p. 583 (1896).

EUTYPELLA (Nits.)

Stroma valsoid, immersed in hard bark or wood, bounded by a black line; perithecia in one or two strata, sometimes circinate, mouth sulcate; asci long-stalked, 8-spored; spores tinged yellow or hyaline, continuous. Conidia and spermogonia often present.

Stem disease of young fruit-trees.—Young standard fruit-trees, more especially apple, pear, and plum, are often killed outright by a fungus called *Eutypella prunastri* (Sacc.). Almonds, cherries, peaches, and apricots suffer to a lesser extent, but do not always escape. The variety of plum called 'Victoria' appears, so far as I have observed, to be most susceptible of all to the disease. The stem or larger branches are attacked, and a tree almost invariably dies the second season after the disease shows itself outwardly, infection having taken place the year previous. The first suggestion of the presence of the fungus is the occurrence of slightly shrunken areas of the bark, which look dry and dead. These diseased areas gradually extend until the stem is completely girdled, and presents a 'bark-bound' appearance. The diseased bark soon becomes covered with myriads of minute raised points, which are the openings of receptacles embedded in the bark, and containing the conidial form of fruit of the fungus. At this stage the mycelium has killed the cambium and entered the wood, choking the vessels and preventing the upward passage of water from the roots. When this stage has been reached the tree dies the following season, after making an attempt at producing leaves. In some instances, where the stem has not been completely girdled by the disease, it may continue to live for another year, but the scanty yellow, wilted foliage clearly indicates that the end is

near. After the tree is dead, the second or ascigerous form of fruit bursts through the bark in larger pustules than those formed by the conidial fruit.

In all the cases I have investigated in the field, the common practice of planting too deep had been followed, and this I feel assured has something to do with the disease, more

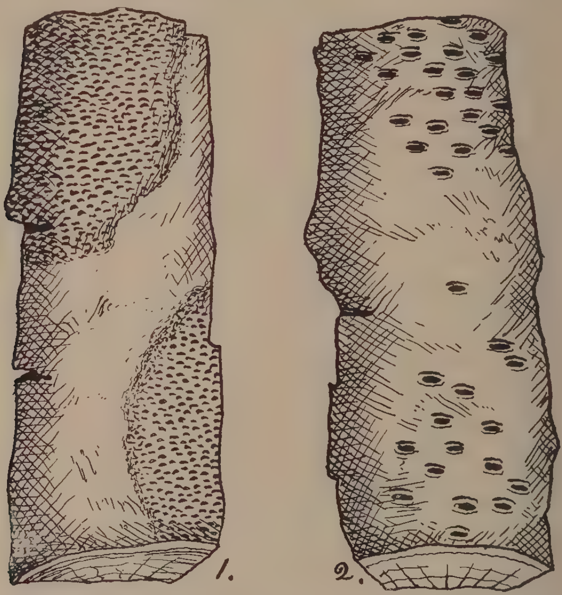

FIG. 43.—*Eutypella prunastri*. 1, portion of stem of young plum-tree showing conidial stage of fungus; 2, portion showing ascigerous stage on the dead bark.

especially when the soil is inclined to be stiff. Under such circumstances numerous large lenticels are formed on the stem, and I have found by experiment that if spores of the conidial condition of the fungus are applied to such lenticels during damp weather infection follows.

To guard against infection from air-borne spores, cover the trunk and branches with a mixture of lime and soft-soap. Diseased trees should be removed and burned.

As the fungus is abundant on the blackthorn, wild plum, and bullace, such should be removed from the neighbourhood of young fruit-trees, which are liable to infection until ten years of age.

Massee, *Gard. Chron.*, Sept. 27, 1902.
" *Journ. Board. Agric.*, 9, p. 361 (1902).

DITOPELLA (De Not.)

Perithecia formed in the bark of the host, immersed, ostiolum protruding; asci many-spored, spores elliptical or ovoid, subhyaline, continuous.

Alder twig blight.—The tips of the twigs are killed by *Ditopella fusispora* (De Not). The bark of the injured parts is of a red-brown colour, which contrasts strongly with the green colour of the healthy portion of the shoot. The fruit of the fungus, under the form of minute black dots, is scattered over the diseased portions.

Spores, 15-25 × 2-3 μ.

Plowright., *Gard. Chron.*, June 17, 1899, p. 392.

GNOMONIELLA (Sacc.)

Perithecia sub-membranaceous, beak central or lateral; asci 8-spored; spores elongated, continuous, hyaline, rarely subfiliform; paraphyses absent.

Alder leaf spot.—Klebahn has shown that the fungus known as *Leptothyrium alneum* (Sacc.), which occurs under the form of minute, shining, black dots—the perithecia—on yellowish spots on living alder leaves, is the conidial stage of the ascigerous fungus (*Gnomoniella tubiformis*, Sacc.).

Conidia sausage-shaped, curved; hyaline, 8·5 × 1·5-2 μ.

Perithecia of ascigerous form develop on dead, fallen leaves in the spring. Immersed, with a stout, long beak protruding from under side of leaf; asci cylindric-clavate, 60-70 × 11-13 μ; 8-spored; spores hyaline, unsymmetrically elliptical, 12-15 × 5-6·5 μ.

Klebahn, *Zeitschr. Pflanzenkr.*, 18, p. 140 (1908).

BOTRYOSPHAERIA (Ces. and De Not.)

Stroma innate, subrotund, brownish; asci clavate, 8-spored; paraphyses present; spores elongated, hyaline, continuous.

Briar scab.—This disease, caused by *Botryosphaeria dothidea* (Ces. and De Not.), now and again appears as an epidemic in a garden, and amongst cultivated roses, it

Fig. 44.—*Botryosphaeria diplodia*. 1, fungus on portion of stem of a wild rose, reduced; 2, ascus containing 8 spores, highly mag.

appears to exercise much discrimination in the choice of a host. In one garden a bed of 'Soleil D'Or,' and another bed of 'Caroline Testout,' about thirty yards apart, had every plant in each bed badly infected, whereas intervening beds of roses showed no sign of disease. Wild roses throughout the country are frequently met with in a diseased condition. The fungus forms large, slightly raised, black scabs, cracked more or less concentrically, on the bark.

Ascigerous condition. Perithecia buried in the black stroma; asci clavate, 8-spored; spores hyaline, continuous, 17-20×8-9 μ.

Conidial form. Minute conidia contained in cavities in the stroma. During summer care should be taken that the disease is not introduced into the garden on briar stocks. If it occurs on cultivated roses these should be cut away below the disease; but sometimes it extends underground, in which case the plant should be removed and burned.

Massee, *The Rose Annual*, 1909 (there called *Byssosphaeria diplodia* by mistake).

Willow canker.—Professor Johnson has described a canker of willow rods caused by *Botryosphaeria gregaria* (Sacc.). The skin of the rod at the infected points looks as if it had been scorched, it dries up, turns brown, and becomes cracked; at a later stage the skin peels off more or less, and exposes the cracked wood. The rods snap at the diseased spots, and are rendered useless for basket-making.

Ascigerous form. Perithecia gregarious, globose, black; asci clavate, 8-spored, with paraphyses; spores oblong-ovoid, hyaline, 30-40×6-8 μ.

Conidial stages are also present.

Care should be taken not to plant diseased sets from an infected source.

The land should be well drained to avoid stagnant water and sour soil. It should also be well manured.

Johnson, *Sci. Proc. Roy. Dublin Soc.*, 10, p. 153 (1904).

GLOMERELLA, Spauld. and Schrenk (= *Gnomoniopis*, Stoneman, not Berlèse)

Perithecia caespitose, or more or less compound and immersed in a stroma, with which they often form an evident hard cushion; asci, oblong to clavate, 8-spored, paraphyses absent; spores oblong, usually slightly curved, continuous, hyaline. Permanent stage of *Gloeosporium*—like fungi.

Gloeosporium is palmed off as being the conidial condition of so many different ascigerous fungi nowadays!

Apple rot.—This disease probably occurs wherever apples are cultivated; it is also found on wild crabs, causing the well-known sunken patches, the flesh of which has a very bitter taste, hence the term 'bitter rot' used in the United States, where the disease is rampant. In 1900 it was estimated that the loss to the apple crop from bitter rot amounted to 10,000,000 dollars for that year. The fungus concerned is *Glomerella rufo-maculans* (Spauld. and Schrenk) with its conidial form *Gloeosporium rufo-maculans* (Spauld. and Schrenk), perhaps better known as *Gloeosporium*

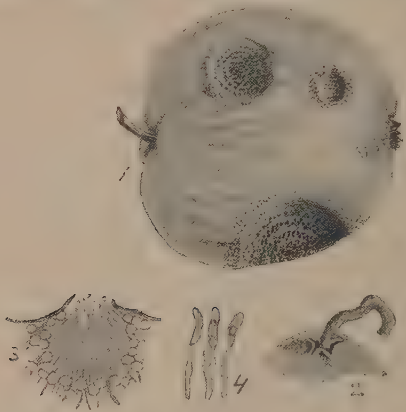

FIG. 45.—*Glomerella rufo-maculans.* 1, apple with conidial form of fungus; 2, the apex of a conidial form of the fungus; the conidia are escaping as a mucilaginous tendril; 3, section through conidial form of fruit; 4, conidiophores bearing conidia. Figs. 2-4 mag.

fructigenum (Berk.). To the grower the fungus is most obvious on the fruit, which at first appears as a faint, light brown speck under the skin of the apple. These spots gradually increase in size, become darker brown in colour, and the surface of the diseased spot gradually sinks below the general level of the surface of the fruit. At a later stage minute black points, usually arranged in concentric circles, appear on the brown spots. These are the *Gloeosporium* condition of the fungus. The conidia are protruded from under the cuticle in the form of sticky tendrils, and form a

pinkish mass of conidia on the brown patches until removed by rain, etc. Many observers have proved that when young apples are inoculated with these conidia, apple-rot follows. As a rule not more than two or three diseased patches occur on an apple, these gradually increase in size, and often cover the entire surface. The disease hastens the period of ripening and causes the fruit to fall prematurely. Until quite recently but little was known respecting the life-history of the fungus causing apple-rot. It had been remarked that trees that had been previously attacked were more liable to produce diseased fruit; it had also been remarked that the disease appeared to spread gradually from an infected tree. Spaulding and Schrenk have shown that the fungus also forms cankers on the branches of apple-trees, and the spores from these cankers bring about the infection of the fruit, a fact which accounts for the fruit high upon the tree first showing the disease. The fungus when present on the branches forms blackened, sunken patches, and the bark is killed for some distance back. The dead bark becomes cracked, or sometimes falls away. The spores of the *Gloeosporium* stage are produced on these diseased patches, and experiments have shown that the spores from a cankered branch will produce the characteristic rot on the fruit, and *vice versâ.* The cankers occur on last year's fruit spurs, also on branches up to four inches in diameter. The *Gloeosporium* condition is met with most abundantly in a state of nature, but pure cultures, commencing with the conidia, have resulted in the production of an ascigerous stage, which also occurs on decaying apples, and has been called *Glomerella rufo-maculans.*

Gloeosporium stage. Pustules dingy rose-red, arranged concentrically on the brown, depressed patches on the fruit; conidia oblong or cylindrical, often slightly bent; hyaline, $20\text{-}30 \times 5\text{-}6\ \mu$; basidia about equal in length to conidia, simple or forked.

Ascigerous stage. Produced on decayed apples, etc., forming a stroma, which is often concealed by dark olive mycelium, and contains the immersed, subglobose perithecia; asci subclavate, fugacious, $55\text{-}70\ \mu$ in length; spores 8; hyaline, sausage-shaped, continuous, $12\text{-}22 \times 3\text{-}5{\cdot}5\ \mu$.

When the fruit is attacked when quite young, it usually remains hanging on the tree in a mummified condition. All such should be removed, and all fruit that has fallen to the

ground should also be collected and burned. All cankers on the branches should also be removed. When on thin shoots the entire shoot should be cut away, in the case of thicker branches, the diseased patches should be cut out, and the wound at once dressed with tar.

Spray with Bordeaux mixture once before the buds open, and again at intervals until the fruit is almost ripe.

Berkeley, M. J., *Gard. Chron.*, p. 245 (1856).
Blair, J. C., *U.S.A. Expt. Sta. Ill.*, *Bull.* 117 (1907).
Schrenk and Spaulding, *U.S. Dep. Agr.*, *Bur. Pl. Ind.*, *Bull.* No. 44 (1903).
Southworth, *Journ. Mycol.*, 6, p. 164.
Stoneman, *Bot. Gaz.*, 26, p. 71 (1898).

POLYSTIGMA (Pers.)

Stroma flat, rather fleshy, tawny or reddish; perithecia immersed; asci 8-spored; spores elongate, continuous; spermogonia usually present.

Forming fleshy, flattened, reddish patches on leaves.

Plum leaf blister.—This disease is caused by *Polystigma rubrum* (D. C.), and attacks cultivated plums and other members of the genus *Prunus*. It also occurs on almond and white thorn. The leaf is the part injured, the fungus forming somewhat large, dull, orange-red patches, obvious on both surfaces of the leaf, but most pronounced on the lower side, where a flat stroma is formed, which is slightly thicker than the substance of the leaf. The red colour of the patches is due to the presence of a reddish-orange, oily substance present in the cells of the fungus. With a pocket-lens numerous very fine punctures may be seen on the surface of a blotch; these are the mouths or openings of globose conceptacles sunk in the stroma, and containing spermatia. These spermatia are produced in immense numbers throughout the summer, but experiments have failed to show that they are capable of producing the disease. After diseased leaves have been lying on the ground throughout the winter, an ascigerous condition of the fruit develops in the stroma, which in the meantime has become blackish, hard, and

brittle. Experiments have proved that the ascospores when placed on the young leaves, germinate, enter the tissues, and give origin to the disease.

Ascigerous form. Stromata flattened, developed on the under surface of the leaf, reddish, then orange-brown, ostiola

FIG. 46.—*Polystigma rubrum*. 1, diseased plum leaves; 2, section through stroma showing perithecia; 3, asci containing spores; 4, spermatia produced in spermogonia. Fig. 1 reduced; remainder highly mag.

sunk in the tissue; asci clavate; 8-spored; spores elliptical, obtuse, straight, subhyaline, $10 \times 6\ \mu$.

Conidial form (=*Libertella rubra*, Bonor.). Spermatia filiform, slightly thickened at one end, curved, 30 μ long.

Prillieux, *Malad. des Plantes Agric.*, 2, p. 91 (1897).

B. *Spores hyaline*, 1-*septate* (=2-*celled*).

NECTRIA (FRIES.)

Perithecia distinct, clustered, or scattered, sometimes produced on a fleshy stroma that has previously borne conidia, fleshy or sub-membranaceous, clear coloured, usually red or orange; asci cylindric-clavate, 8-spored; spores hyaline, elongated, 1-septate.

Distinguished by the soft—not carbonaceous, highly-coloured perithecia.

Winter rot of potatoes.—Probably the most destructive disease attacking stored potatoes, where it is practically always present to some extent. The most usual symptom of the presence of the fungus is the gradual sinking and wrinkling of the surface of the tuber. These sunken places soon become sprinkled over with small, snow-white tufts of a conidial form of fruit. When the tissue becomes disintegrated by the mycelium, other organisms, bacteria, fungi, mites, etc.,

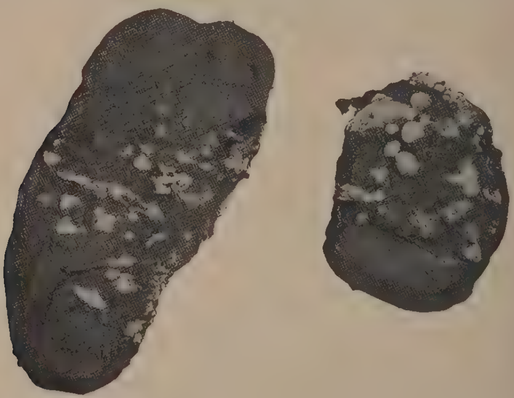

FIG. 47.—*Nectria solani.* The *Monosporium* and *Fusarium* stage; the most frequently observed condition of 'winter-rot' in potatoes.

quickly enter and assist in reducing the tuber to a semi-liquid, rotten, strong-smelling mass.

The disease has usually been attributed to *Fusarium solani* (Pers.), but in reality the proper name of the fungus is *Nectria solani* (Reinke and Berthold), of which the *Fusarium* is a conidial form. The reason why the *Fusarium* has been considered as the primary and only cause of the disease is because it is the most conspicuous feature present during the state of disease most usually met with, and further, because the *Fusarium* condition is capable of continuing the disease alone, or without the intervention of the other phases

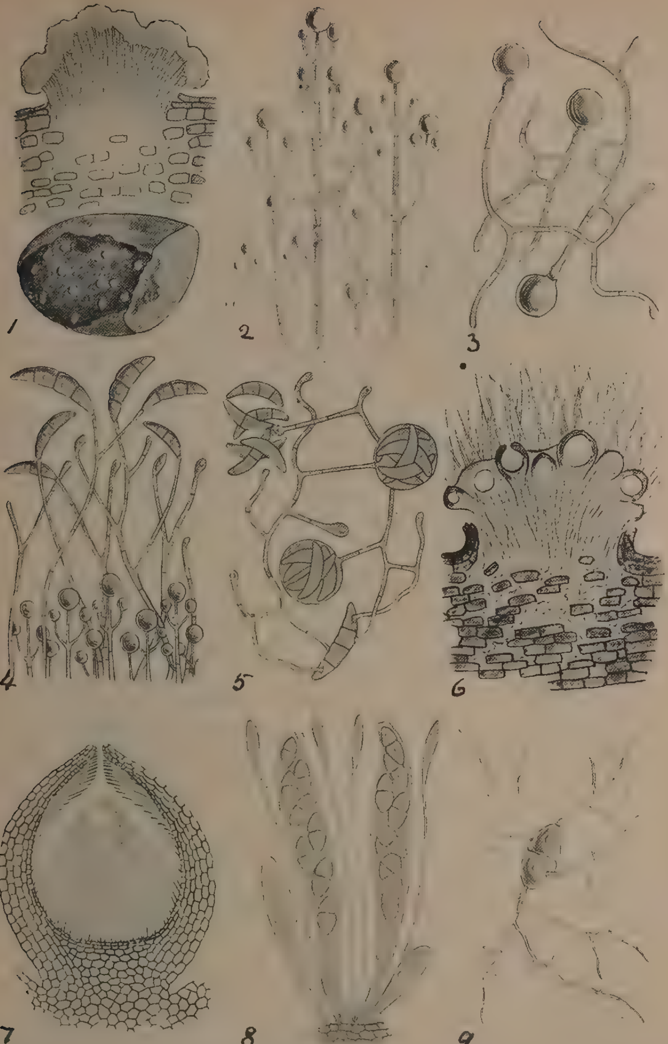

FIG. 48.—*Nectria solani*, figures illustrating its life-cycle. 1, portion of a diseased tuber, and section through a conidial stroma; 2, *Monosporium* fruit; 3, conidia of same germinating; 4, *Fusarium* stage, following the *Monosporium* condition; 5, *Fusarium* conidia, germinating and producing the *Cephalosporium* stage; 6, stroma that has produced *Monosporium* and *Fusarium* conidia, bearing young perithecia, or the commencement of the ascigerous condition; 7, section of a mature perithecium; 8, asci containing spores, also paraphyses; 9, ascospore germinating. The tuber in Fig. 1 reduced; the remainder highly mag.

belonging to the most complete cycle of development of the fungus.

If a tuber showing the incipient stage of the disease, before the fungus has burst through the skin, is placed in a two per cent. solution of formalin in water, for ten minutes, for the purpose of destroying superficial germs, and afterwards rinsed in distilled water and placed in a damp atmosphere at a temperature of about 70° F., scattered, cushion-like, snow-white tufts of the fungus will burst through the periderm or skin of the potato on the shrunken patches within a few days, or a week at most. These first tufts I invariably find to consist of the *Monosporium* stage of the fungus (Fig. 2, life cycle of *Nectria solani*). When this phase has been present for a few days, the exact time depending on the amount of chemical change effected on the host by the fungus, the *Monosporium* stage ceases to develop, and the second or *Fusarium* form of fruit appears on the same tufts that previously produced *Monosporium* conidia (Fig. 4). The *Fusarium* condition often remains, producing a succession of conidia for several weeks, the period of time being mostly determined by the relative activity of secondary organisms in effecting the complete rotting of the tuber. When the *Fusarium* conidia are germinated in a hanging-drop, one or more irregularly branched germ-tubes are produced by each conidium, and on these germ-tubes are produced at intervals, at the tips of short lateral branches, the clustered spores of the *Cephalosporium* stage (Fig. 5). This is the last of the conidial phases of the fungus. The pulvinate tufts or stromata that produced the *Monosporium* and *Fusarium* phases still remain embedded in the old and empty skin of the potato, and during the following season produce the ascigerous form of fruit, the spores of which on germination produce secondary spores. Whether these secondary spores are capable of infecting young growing tubers I do not know; all my experiments in this direction have failed. When conidia of the *Monosporium* and *Fusarium* stages are sown in culture media, each one continues to reproduce its own kind. In such cultures the mycelium is sometimes coloured deep blue, red, or salmon-colour. I have succeeded in infecting young tubers with *Fusarium* conidia, but not with those of *Monosporium*. The conidia of the *Cephalosporium* stage persistently refused to germinate.

The fact that the *Nectria* or ascigerous condition is only formed on the old dead skin of the potato the season following the appearance of the conidial condition, perhaps accounts for its not being previously connected with the disease.

Ascigerous form. Perithecia crowded on a stroma, minute, conic-globose, smooth, blood-red, asci clavate, 8-spored; spores elliptical, hyaline, 1-septate, slightly constricted at the septum, $8\text{-}9 \times 5\ \mu$; paraphyses slender, tips strongly clavate.

Monosporium stage. Conidiophores usually with pairs of branches at different levels, branches bearing opposite branchlets, each terminated by a minute, globose, hyaline conidium $4\text{-}6\ \mu$ diam.

Fusarium stage. Conidiophores elongated, simple or branched, conidia hyaline, fusiform, arcuate, 3-5-septate, $15\text{-}40 \times 5\text{-}8\ \mu$, but size very inconstant and variable.

Cephalosporium stage. Conidiophores short, simple, springing as lateral branches from creeping hyphae that often run in parallel fascicles or strands, conidia produced in a cluster at the tip of the conidiophore, where they become free, but are fixed at the apex of the conidiophore for some time in a globular mass of mucilage, resembling the head of a *Mucor*, conidia *Fusarium*-shaped, hyaline, becoming septate, $6\text{-}12 \times 3\text{-}4\ \mu$.

The tubers are probably infected while growing, but sometimes there is no sign of disease when they are lifted. If thoroughly dried before storing no further development takes place, whereas if sweating occurs after storing, the disease spreads rapidly. When storing, powdered sulphur at the rate of about 2 lb. to the ton should be sprinkled over the potatoes. This checks the development of the fungus, and also destroys mites, etc., that convey the spores from one potato to another, where infection takes place through wounds.

Land that has produced a diseased crop is certain to be infected, and should be dressed with kainit or lime.

Board of Agric. Leaflet, No. 193.

Apple-tree canker.—This well-known disease is caused by *Nectria ditissima* (Tul.), which by no means confines its attacks to this tree, but is equally common on beech, oak, hazel, ash, hornbeam, maple, lime, dogwood and bird-cherry.

I have also seen it on the gooseberry in such quantity as to kill the branches.

The fungus is a wound-parasite, and it frequently follows on the wounds caused by American blight (*Schizoneura lanosa*), since the advent of which, canker has been much

FIG. 49.—*Nectria ditissima.* 1, a branch recently attacked, showing concentric cracking of the bark; 2, an old wound showing a rugged callus round the wound; 3, section through a stroma showing perithecia, *a*, on its surface; 4, a perithecium; 5, section of same; 6, conidia; 7, a conidium germinating; 8, ascus containing spores, and accompanied by paraphyses. Figs. 1 and 2 reduced; remainder highly mag.

more prevalent, and perhaps it is not going too far to state that if we had no American blight or woolly aphis, we should have no epidemic of canker. The bark is first attacked and destroyed, often cracking in a concentric manner. After-

wards the wood is also destroyed, the canker often completely girdling small branches, which are then easily broken off by wind. As a rule a rugged callus forms round the wound, and frequently new canker spots appear on a branch at points where there is no evidence of external inoculation, and Hartig considers that the mycelium travels under the bark for some distance from a point of infection. At those points where the mycelium is most vigorous, minute, small, white cushions or stromata appear in the autumn, bearing on their surface minute conidia. During the following spring clusters of small, bright-red perithecia appear on the edges of the wound.

Perithecia usually in dense clusters, globose, papillate, blood-red, asci cylindric, 8-spored, spores ovate-oblong, 1-septate, hyaline, $14 \times 5\text{-}6\ \mu$.

Conidial form (*Tubercularia crassostipitata*, Fckl.). Conidia ovate-oblong, continuous, $6\text{-}8 \times 3\text{-}4\ \mu$.

Badly diseased branches should be removed and burned. Where the canker is slight, or when it is located on the larger branches, the diseased portions should be cut out, and the wounds at once dressed with gas-tar. Old, cankered trees are too frequently allowed to remain standing after they are useless. All such should be removed and burned.

The American woolly aphis and green fly should be kept down by the use of insecticides.

Hartig and Somerville, *Diseases of Trees*, p. 91.

Spruce Nectria (*Nectria cucurbitula*, Fr.) has been shown by Hartig to be a destructive wound-parasite, attacking more especially the spruce, less frequently the silver fir and Scots fir. The bark is the part attacked, an entrance being effected through wounds made by the larva of the moth called *Grapholitha pactolina*, also through bruises caused by hailstones or broken branches. Both conidia and ascophores are capable of infecting the tree; the spores germinate on the resin surrounding a wound, and the mycelium penetrates to the cambium zone, where it is enabled to live and spread throughout the year. From thence it extends to the wood and flourishes most luxuriantly in the sieve-tubes and soft bast, growing most actively during the winter months when the growth of the tree is at a standstill. Some time after infection the bark is killed and dries up during the summer,

and the branch attacked dies beyond the point of infection. When the disease is general the leaves towards the top of the tree turn yellow, and soon afterwards the tree dies. In some instances, especially during a dry season, the fungus does not form fruit, but when the bark remains damp, numerous minute, white tufts of the conidial form appear first, followed by dense clusters of minute red perithecia, which under favourable conditions often almost completely cover the bark.

Fusarium stage. Conidia fusiform, slightly curved, hyaline, 1-5-septate, length very variable.

Ascigerous form. Perithecia subglobose, vermilion, polished, shortly and obtusely papillate, not collapsing when old, asci cylindrical, slightly constricted just below the apex, shortly stipitate, 8-spored, $100\text{-}110 \times 9\text{-}10\ \mu$; spores 1-seriate, elliptic-oblong, 1-septate, constricted at the septum, hyaline, $14\text{-}18 \times 6\text{-}7\ \mu$.

It is suggested that diseased trees should be removed to prevent the spread of the disease. This, however, appears to be impracticable on a large scale.

Hartig, *Unters. aus dem Forstbot. Inst. zu München*, i. p. 88.

Hartig and Somerville, *Diseases of Trees*, p. 89.

Prillieux, 2, p. 83 (1879).

Coral spot disease (*Nectria cinnabarina*, Fries.) has usually been considered as a saprophyte, and in many instances certainly is such, covering dead branches, pea-rods, etc., with its brilliant fruit. In other instances it is a true wound-parasite, attacking various trees, sycamore, lime, horse-chestnut, and more especially red currant. The numerous bright, coral-coloured warts, about the size of a millet seed, thickly studded over the surface of dead branches, are familiar to most people. These are the conidial condition of the fungus. During the winter these red pastules bear the ascigerous condition of the fungus, the perithecia of which are minutely warted and of a dull, brownish-red colour.

Perithecia clustered on the pinkish conidial stroma, spherical, corrugated, brownish-red, asci 8-spored, spores oblong, ends obtuse, 1-septate, $14 \times 5\text{-}6\ \mu$.

Conidial form (= *Tubercularia vulgaris*), coral-red, pulvinate, conidia hyaline, $6\text{-}8 \times 1{\cdot}5\text{-}2\ \mu$.

The mycelium extends much beyond the point indicated by the fungus on the surface, hence cuttings should not be taken from diseased plants. Diseased branches should be removed and burned, as should also infected branches and twigs lying on the ground.

Mayr, *Unters. Forstbot. Inst. München*, iii. p. 1.

Cacao trunk disease.—Mr. J. B. Carruthers has published a report on this disease in Ceylon, of which the following is a summary. The fungus concerned is obviously a species of *Nectria*, allied to the disease causing apple-tree canker. The earliest indication of the disease is a darkening of a patch of the bark; if this patch is cut out it is found to be soft, of a claret colour, and full of moisture. At a later stage minute white pustules appear, especially in cracks; these eventually become pink. During the white stage, very minute, oval conidia are produced in immense numbers, and later on larger crescent-shaped conidia appear. Finally, when the cortex is dead, or nearly so, a third ascigerous form of fruit appears, the sporangia being globose and grouped in clusters.

The disease often spreads rapidly; in one instance, a diseased patch more than two feet long, and reaching almost round the tree, had formed ten days after inoculation.

The most satisfactory method is to cut out the diseased patch, along with a margin of apparently sound bark. Covering the wound with tar is recommended.

Carruthers, *The Tropical Agriculturalist*, Nov. 1, 1898, p. 359.

Pigeon-pea and pepper wilt.—A dangerous disease attacking the pigeon-pea (*Cajanus indicus*) in India, is described by Dr. Butler. The symptoms are as follows: at first withered plants show here and there when the seedlings are a few inches high, other plants near those first attacked dry up, and patches of dead plants become more frequent as the season progresses. A period of hot, dry weather during the rains favours the disease, and large patches of withered plants appear with startling rapidity. On examination of a badly diseased plant, the root is found to be blackened and dead, blackish streaks also extend up the branches for some distance, and may be seen on removing

the bark. The injury is caused by a species of *Nectria*, the mycelium of which fills the vessels of the wood, thus preventing the passage of water upwards in the plant.

No direct treatment is practicable, but as the fungus exists in the soil, a longer system of rotation is suggested.

The pepper vine wilt is considered to be in many instances due to the injury caused by the same species of *Nectria* that injures the pigeon-pea. In some instances the pepper suffers from the presence of an eelworm (*Heterodera radicicola*), but wilt occurs in many instances in the absence of the eelworm, and even when the latter is present, the fungus is also present, and is considered as the primary source of disease.

Cephalosporium and *Fusarium* forms of the *Nectria* have been observed, but no diagnosis are given.

Butler, *Agric. Journ. of India*, 1, p. 25 (1906).

Cacao pod blotch (*Nectria Bainii*, Massee) causes semi-circular dark blotches on the pods, the diseased portions becoming soft and watery. At a later stage the blotches become covered with a velvety, interwoven layer of yellowish, rust-coloured, or orange mycelium, which is studded over with the minute, orange-red perithecia.

Perithecia red or orange-red, woolly, becoming bald at the apex, 300-350 μ diam. Asci cylindric-clavate, 8-spored. Spores elliptic-oblong, ends subacute, 1-septate, $10\text{-}12 \times 5$ μ.

Massee, *Kew Bulletin*, Jan. and Feb., 1899.

Nectria ipomeae (Halst.) in the *Fusarium* or conidial condition causes a stem-rot of the egg-plant (*Solanum melongena*, L.) and sweet potato (*Ipomaea batatas*, Poir.), covering the withered stems with a white mould. At a later stage, clusters of flesh-coloured perithecia appear. The disease usually commences near the ground-line and extends both into stem and root.

Perithecia in little clusters, acutely papillate, squamulose, red. A *Fusarium* stage is present.

Nectria vandae (Wahrl.) is parasitic on the root of *Vanda suavis* in cultivation.

Perithecia solitary or in small clusters, pear-shaped, red, scurfy, spores $8\text{-}10 \times 4{\cdot}5$ μ. Conidia cylindrical, ends

rounded, $20\text{-}30 \times 3{\cdot}5\text{-}4{\cdot}5\ \mu$, on long conidiophores, forming dense tufts.

Nectria goroshankiniana (Wahrl.) is parasitic on the roots of *Vanda tricolor*.

Perithecia solitary or in small clusters, deep red, squamulose, spores, $12\text{-}15 \times 4\text{-}5\ \mu$. Conidia as in *N. vandae*.

The above two species are described in detail by Wahrlich in *Bot. Ztg.*, July 23, 1886.

Nectria theobromae (Massee) occurred on a 'bleeding' patch of bark of a cacao-tree from Grenada, W. Indies. This appears to be one of the species of *Nectria* that forms 'bleeding' wounds on the bark of the cacao-tree. *Nectria Bainii* (Massee), previously described as forming similar wounds on cacao pods, differs from the present species in having the perithecia shaggy with golden-yellow, scale-like hairs.

Perithecia smooth, orange-red, asci cylindrical, 8-spored, paraphyses present, spores elliptical, 1-septate, $28\text{-}30 \times 8\text{-}10\ \mu$.

Massee, *Kew Bulletin*, p. 218 (1908).

SPHAEROSTILBE (Tub.)

Perithecia, asci, and spores as in *Nectria*, but the perithecia accompanied by a *Stilbum*-like conidial stage.

American coffee disease.—Until quite recently *Stilbum flavidum* (Cooke) was supposed to be the cause of this disease; it is in reality yet the cause, but the *Stilbum* has been shown to be the conidial form of a fungus that has been called *Sphaerostilbe flavida* (Mass.). The disease has been recorded from Costa Rica, Guatemala, New Granada, Venezuela, Nicaragua, Dutch Guiana, and Brazil. The conidial form attacks the foliage, berries, and young shoots. On the leaves the fungus forms circular, whitish spots up to ¼ in. across, that show on both surfaces of the leaf. Such leaves soon fall, and within a month the trees of an entire plantation may be entirely destitute of leaves, yet loaded with berries, which, however, do not reach maturity. One or two white spots appear on diseased berries. On the young shoots the spots are whitish and usually elongated. After the spots have been in evidence for a short time, the surface becomes studded with the fruit of the fungus, under

the form of miniature pins with pale yellowish heads, and 1-2 mm. high.

During January 1908 a large consignment of diseased berries was received at Kew from Costa Rica. The berries

FIG. 50.—*Sphaerostilbe flavida.* 1, leaf showing disease; 2, section showing conidia form; 3, surface view of white spot bearing conidial stage of fungus; 4, section showing perithecia; 5, two perithecia; 6, ascus containing eight spores. Fig. 1 reduced; remainder mag.

had been carefully packed, and arrived in a good condition for experimenting with. These were placed in Petri dishes on sterilised damp blotting-paper. At the expiration of seven weeks dense groups of minute, bright-red perithecia

appeared on the white patches present on one of the diseased berries. A few days afterwards, similar perithecia appeared mixed with the *Stilbum* stage on a second berry. On examination these perithecia proved to be of the *Nectria* type, but a *Nectria* that develops along with a *Stilbum*-like conidial condition, is at the present day referred to the germs *Sphaerostilbe.*

The leaves of three young coffee plants, two years old, were infected with the spores of the *Sphaerostilbe* stage of the fungus, and at the expiration of thirteen days the points of infection became yellowish-green in colour, and during the succeeding week the characteristic white patches, bearing the conidial form of the fungus, were developed. The ascigerous condition did not follow, and it possibly does not develop on the leaves, owing to lack of nutrition, but only on the fruit and shoots. This is what happens in other species of parasites, as *Sphaerotheca pannosa*, etc.

Failure attended numerous attempts to infect young leaves with the conidia of the *Stilbum* phase of the fungus; this has also been the experience of other investigators, in fact no one has yet induced these supposed conidia to germinate, and it is just possible that the conidial condition, although still present, has reached an effete stage, and is no longer of functional value as a reproductive body.

Stilbum-like conidial stage. Forming white spots on leaves, fruit, and young shoots; conidiophores gregarious, consisting of a fascicle of hyphae expanding into a head at the apex, each hypha terminated by a swollen cell bearing several slender outgrowths each bearing a minute conidium $1 \cdot 5$-2 μ diam., conidiophores 1-2 mm. long, entirely pale yellow.

Ascigerous stage. Perithecia gregarious, warted, bright red; asci cylindrical, 8-spored; spores hyaline, 1-septate, elliptical, ends acute, 15×6-7 μ.

The most important, practicable measures for eradicating the disease are the following. All diseased shoots should be removed and burned, as the perithecia produced on the bleached spots will furnish spores which will infect fresh leaves, fruit, and shoots.

All diseased fruit, whether hanging on the trees or lying on the ground, also all dead leaves, should be collected and either burned or deeply buried. Imperfect aeration of the soil, and allowing the lowermost branches to remain on the

tree, favour the disease, as an imperfect circulation of air results, and the rubbish cannot be removed from under the trees.

Cooke, M. C., *Grevillea*, p. 11 (1880).
Spegazzini, *Revista Agric.* and *Veter. La Plata*, No. 22, Oct. 1896.
Massee, *Kew Bull.*, 1909.
Puttemans, *Bull. Soc. Myc. France*, 20, p. 157 (1904).

HYPOMYCES (Fries.)

Perithecia gregarious or crowded on a byssoid stroma, bright coloured, soft, asci 8-spored; spores elongated, 1-septate, hyaline.

Conidial forms often present.

Parasitic on various kinds of fungi, perithecia often rosy or red.

Mushroom disease.—Cultivated mushrooms are frequently destroyed in a wholesale manner by *Hypomyces perniciosus* (Magnus). They are frequently attacked before they break through the soil, and on appearing above-ground are covered with a dense white weft of mycelium. Such mushrooms rarely increase in size, but rot and decay. The mycelium of the parasite grows along with that of the mushroom from the first, and when the latter is not destroyed in the early stage, continues to increase in size as a distorted, shapeless mass, the cap is rarely formed and if it is developed the gills are morbid and irregular. Finally every part decays, forming a deliquescent, evil-smelling mass. Up to the present the conidial form of the fungus has alone been observed, the conidia of which impart a tinge of rose-colour to the mycelium on the rotting mushroom.

Conidial form (*Mycogone perniciosus*, Magnus). Mycelium forming a velvety stratum; conidia solitary on short, lateral branches, more or less pear-shaped, 1-septate, almost colourless under the microscope, upper cell almost globose, minutely warted, much larger than the lower, smooth cell, $17\text{-}22 \times 9\text{-}12\ \mu$.

A *Verticillium* stage is also said to be present. When the disease appears, the entire bed as a rule becomes infected. In such cases the spores are present in the soil and dung,

which should consequently be cleared out and spread over grass land. If in a house, after the soil has been removed, every part of the structure should be thoroughly drenched with a solution of sulphate of copper—one pound to fifteen

FIG. 51.—*Hypomyces perniciosus.* 1, mushrooms deformed by the fungus, half nat. size; 2, conidia of the fungus, highly mag.

gallons of water; this should be repeated twice at an interval of about three weeks.

Journ. Bd. Agric. Leaflet, No. 139.
Magnus, *Verh. Ges. Deutsch. nat. u. Aerzte*, 60, p. 246.
Stapf, *Verh. zool.-bot. Gesell.*, 39. p. 617.

SPHAERELLA (CES. and DE NOT.)

Perithecia membranaceous, subglobose or depressed, covered by the epidermis or bursting through; asci 8-spored; spores elongated, 1-septate, hyaline; paraphyses absent.

Strawberry leaf spot.—Both cultivated and wild strawberries are often severely damaged by a fungus named *Sphaerella fragariae* (Tul.), the conidial form of which was at one time the only stage known, and was called *Ramularia Tulasnei* (Rab.). Small reddish-brown patches first appear on the leaves, which continue to increase in size for some time and frequently encroach on each other, forming

FIG. 52.—*Sphaerella fragariae.* 1, a diseased strawberry leaf; 2, ascus containing eight spores of the *Sphaerella* or ascigerous stage; 3, conidia of the *Ramularia* or conidial stage. Figs. 2 and 3 highly mag.

irregular patches. By degrees the centre of the patch assumes an ashy-grey or almost white colour, and is bounded by a reddish border, which is often quite bright in colour later in the season. The central portion then becomes studded with very minute white tufts of the conidial form of fruit. Later in the season these minute white tufts are replaced by minute black points—the ascigerous phase of the fungus. Minute sclerotia are also frequently formed in abundance on diseased fading leaves. This pest is everywhere present

in this country, and is also too well known on the continent and in the United States. When the injury is severe the crop of fruit is much reduced both in quantity and quality; the plants are also weakened for the following season.

Ascigerous form. Perithecia often arranged in concentric rings, globose, black, bursting through the epidermis, 90-130 μ diam. Asci oblong, 8-spored, 40 μ long; spores hyaline, 1-septate, slightly constricted, $15 \times 3\text{-}4\ \mu$.

Conidial form. Conidia bursting through the epidermis in tufts on the whitish spots; conidia narrowly elliptic-oblong, continuous or 1-3-septate, variable in size, $20\text{-}50 \times 2{\cdot}5\text{-}4\ \mu$, hyaline.

If spraying is commenced sufficiently early, in fact where the disease has previously been present, spraying should be commenced when the leaves are quite young, using potassium sulphide solution—an epidemic may be arrested. This treatment will also arrest the possible appearance of strawberry mildew. Spraying should be continued at intervals until the flowers begin to open.

Professor Trelese, who has carefully studied the disease in the United States, advises the following method for eradicating the disease,. a method which I have proved on more than one occasion to be highly successful. 'The most convenient way of effecting this is by mowing badly rusted beds soon after the fruit is gathered, covering the dry tops with a light coating of straw, or harrowing up the old mulching, and burning them. This may seem harsh treatment for the plants, but it has been resorted to by many berry-growers for the destruction of insects with most satisfactory results; and every one who has tried burning over a strawberry bed has been surprised by the vigorous and healthy appearance of the new foliage which soon unfolds.

Prillieux, *Malad. des Plantes Agric.*, 2, p. 268 (1897).

Beet and mangel rot.—A disease doing much damage in this country and on the continent. It is caused by *Sphaerella tabifica*, Prill. and Del. (=*Phoma betae*, Frank, and *Phyllosticta tabifica*, Prill. and Del.). About the month of August the leaves droop to the ground, as is frequent during hot, dry weather; this drooping, however, is permanent, and is caused by the fungus attacking the upper surface of

the leaf-stalks. Its presence is indicated by the white patches bordered with orange-red. The fungus passes from the leaf-stalks into the root, penetrating to the heart, causing a rot. The conidial fruit first appears on the leaf-stalks, followed by the ascigerous form when the leaves are quite dead.

Ascigerous form. Perithecia rounded, brown, asci oblong-clavate, 8-spored; spores hyaline, 1-septate, upper cell ovate-rounded, largest, lower cell narrower, $21 \times 7\cdot5\ \mu$.

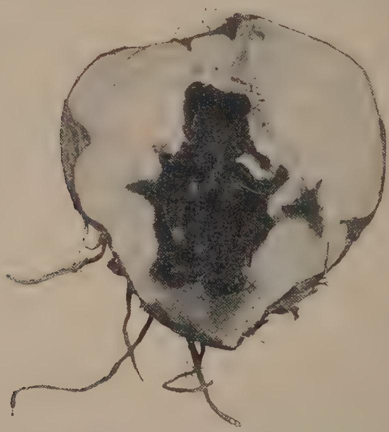

FIG. 53.—*Sphaerella tabifica*, causing heart-rot of orange-globe mangold.

Conidial form. Perithecia subglobose, conidia elliptical, hyaline, $5\text{-}7 \times 3\cdot5\ \mu$, escaping as a gelatinous tendril.

As the disease appears somewhat late in the season, it is advisable to lift the crop when it is first observed, before the fungus passes from the leaves into the root. Diseased 'tops' should be collected and buried. It is important not to include diseased roots when storing, and if diseased roots are found when the pits are opened they should not be thrown on the manure heap or into the pig-stye, but buried, otherwise the disease will find its way back to the land.

Frank, *Zeitschr. Zucherr.*, 1892, p. 904.
M'Weeney, *Journ. Roy. Agric. Soc.*, Ser. 3, 6, pt. 3 (1895).
Prillieux, *Malad. des Plantes Agric.*, 2, p. 263 (1897).

Pear leaf fleck (*Sphaerella sentina*, Schröt.).—This fungus has long been known as *Septoria piricola* (Desm.), but Klebahn has recently demonstrated that the *Septoria* is only a conidial form of *Sphaerella*, an ascigerous genus. The conidial condition forms numerous small, greyish-white specks, most obvious on the upper surface of the living leaves. When the leaves are dead the ascigerous condition of the fungus appears under the form of minute, scattered, or crowded, blackish points. Most frequent on pear leaves, although occurring on apple leaves also.

Septoria stage. Minute black perithecia scattered on small bleached spots on living leaves. Conidia elongated, slender, curved, pale olive, $55\text{-}60 \times 3\text{-}4\ \mu$, escaping in a tendril.

Sphaerella form. Perithecia partly immersed, papillate, asci cylindrical, spores 1-septate, resembling two cones joined by their bases, pale olive, $15 \times 5\ \mu$.

When severely attacked the leaves fall early in the season and affect the crop. An important point is to collect and burn infected dead leaves, as the spores on these start the disease the following season.

Klebahn, *Zeitsch. für Pflanzenkr.*, 18, p. 5 (1908).

Blight of cereals.—It often happens that after a period of dry weather followed by more or less continuous rain, in the month of June, that wheat and other cereals assume a yellow tint, followed by a shrivelling and bleaching of the leaves which become covered with little, blackish, olive tufts, which are the clustered conidia-bearing branches of a fungus best known in this country under the name of *Cladosporium herbarum* (Pers.), but which in reality is a conidial form of *Sphaerella Tulasnei* (Janczewski). In many instances the plants are killed outright, leaving bare patches here and there in the field, or a thin crop is the result. At other times when the disease appears later in the season, the grain is attacked and covered more or less with the fruiting bodies of the *Cladosporium* stage, which give to it a blackened appearance. Such grain imparts to flour a very unpleasant flavour. I have shown elsewhere that the forms called *Dematium pullulans* and *Hormodendron cladosporoides* are respectively conditions only of *Cladosporium herbarum.* Janczewski arrived independently at the same conclusion, and in addition, by means of pure cultures, proved

Cladosporium herbarum to be the conidial condition of *Sphaerella Tulasnei*. Lopriore has shown that diseased grains as a rule do not germinate, but those that do grow produce diseased plants, which clearly show the mycelium of *Cladosporium*, under the form of long, reddish-brown specks, even in the first leaf-sheath.

Ascigerous condition. Perithecia subglobose, minute, asci cylindric-fusoid, 8-spored; paraphyses absent; spores hyaline, oblong, ends rather pointed, 1-septate, the uppermost cell in the ascus is usually slightly larger than the remainder, and measures $28 \times 6 \cdot 5\ \mu$.

Cladosporium form. Tufts dense, forming a velvety, blackish, olive, effused patch, conidiophores erect, septate, rarely branched, often nodulose or kneed. Conidia often forming chains of 2-3, subcylindrical, pale olive, 1-3-septate $10\text{-}35 \times 4\text{-}7\ \mu$.

Hermodendron form. Stem erect, simple, bearing at apex, or laterally, a tuft of small, elliptical, continuous brown conidia borne in simple or branched chains. This form is often produced from broken ends of *Cladosporium* conidiophores when placed in a hanging drop.

Janczewski, *Extr. Bull. Acad. Sci. Cracow*, 1892-93-94.
Lopriore, *Sonder. aus Landwirth. Jahrb.*, 23 (1894).
Massee, *Kew Bull.*, 1898, p. 321.
Prillieux, *Malad. des Plantes Agric.*, 2. p. 252 (1897).

A difficult disease to combat, as the *Cladosporium* condition is one of our commonest of saprophytic fungi, growing everywhere on dead and decaying vegetable matter. As it is known that infected grain perpetuates the disease, it is important that untainted seed only should be sown.

Mulberry leaf rust.—The leaves of mulberries are frequently destroyed to a serious extent by *Sphaerella morifolia* (Passer). The leaves are infected in spring by the conidial form of the fungus, one known as *Cylindrosporium mori* (Berlèse) and *Septogloeum mori* (Briosi and Cav.). Diseased leaves show a number of irregularly shaped blotches, pale brown in colour with a darker edge. The fruit of the fungus appears in irregular circles of small brown dots on the patches, mostly on the upper surface of the leaf. The spores of this form are quickly diffused and infect other leaves; this continues throughout the growing season. Injured

leaves soon become yellow and dry, and when the disease is abundant, early defoliation affects the fruit and also injures the tree. The ascigerous form of fruit is found during the winter on fallen leaves that had been attacked by the conidial form of the fungus.

Silkworms may be fed on leaves attacked by the fungus without experiencing any injury, only the green, healthy portions of the leaf being eaten.

Ascigerous form. Perithecia hypophyllis, superficial, black; asci short, base inflated, $50\text{-}55 \times 10\text{-}15\ \mu$, spores oblong, cuneate, hyaline, 1-septate, $17\text{-}25 \times 5\text{-}5{\cdot}5\ \mu$.

A damp season favours the disease, and trees planted in damp situations suffer most severely. When the leaves are required for silkworms, spraying with Bordeaux mixture cannot be practised, otherwise if sprayed early in the season some good might result, but so far as I am aware, this method has not been tested. As infection depends on the presence of the ascigerous form of the fungus growing on the dead, fallen leaves, all such should be collected and buried.

Berlèse, *Fungi Moricolae*, p. 24.
Prillieux, *Malad. des Plantes Agric.*, 2, p. 280 (1897).

MYCOSPHAERELLA (Johans.)

Perithecia as in *Sphaerella*; asci containing sixteen 1-septate, hyaline spores; paraphyses absent.

GNOMONIA (Ces. and De Not.)

Perithecia seated in the tissue of the host, glabrous, with a central or lateral, elongated ostiolum; asci 4-8-spored; spores elongated, hyaline, 1-septate; paraphyses absent.

Minute fungi usually growing on leaves, the beak or ostiolum is elongated and projects beyond the surface of the leaf.

Cherry leaf scorch (*Gnomonia erythrostoma*, Auersw.) is well known as the cause of a serious cherry-tree disease, both in this country and on the continent. The symptoms are very characteristic, and cannot be mistaken for any other kind of injury. The leaves are attacked during the summer by the conidial stage of the fungus, which occurs under the form of

numerous minute, erumpent perithecia situated on large discoloured patches. The mycelium of the conidial form spreads rapidly in the tissues of the leaf and passes into the leafstalk, cutting off the supply of food, consequently the leaves are killed early in the season, and as in all such cases where leaves are killed early in the season through lack of food, remain hanging on the tree throughout the winter, and even

FIG. 54.—*Gnomonia erythrostoma*. Branch with persistent, drooping, dead leaves.

the following season after the new leaves have appeared. The fruit is also attacked at times, when it becomes distorted and ripens unevenly. During the winter months the higher or ascigerous form of fruit is developed on the dead, hanging leaves. The spores produced by this form of the fungus infect the young leaves the following season.

The perithecia of the conidial form are very minute, and burst through the epidermis of the leaf, ostiolum not elongated ; sporophores branched ; spores filiform, hyaline, slightly curved, terminal or originating from the nodes of the sporo-

phore, 14-20 $\times$ 1-1·5 μ. Perithecia of ascigerous form with an ostiolum or beak projecting beyond surface of leaf; asci 8-spored; spores hyaline, narrowly ovate, 1-septate below the middle, 16-18 $\times$ 5-6 μ.

Collecting and burning all the hanging leaves during winter is the only practical method of stamping out the disease. This practice, however, should be general in an infected district, otherwise it is of little avail, as the spores are blown

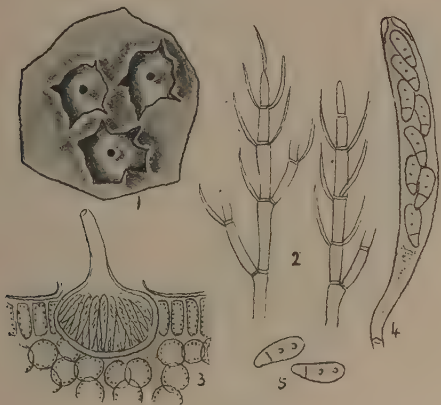

FIG. 55.—*Gnomonia erythrostoma*. 1, conceptacles containing spermatia bursting through the epidermis of a leaf; 2, spermatia; 3, section of perithecium of ascospore stage; 4, ascus containing spores; 5, free spores. All mag.

from one orchard to another. Frank records an instance in Prussia where the cherry industry was completely wrecked by this disease, but after two years' work in collecting and burning all infected leaves, the epidemic was thoroughly stamped out, and a return to the former productiveness followed.

Wild cherries growing in woods and the bird cherry (*Prunus avium*) are also attacked by this disease, and may prove a source of infection unless attended to.

Plane leaf scorch.—This is a very destructive disease, attacked trees being often completely defoliated before the end of July. The injury usually appears about the time when

the leaves are full-grown, under the form of brownish patches which generally follow the course of the larger veins. The leaves fall long before they are dead, owing to the mycelium of the fungus passing into the leafstalk, and cutting off the supply of food and water. Minute spore-clusters are formed

FIG. 56.—*Gnomonia veneta.* 1, a diseased plane leaf, somewhat reduced ; 2, conidia, highly mag.

along the course of the veins on the under surface of the leaf. This disease was considered to be due entirely to *Gloeosporium nervisequum* (Sacc.). Klebahn, however, has recently worked out the life-history of the fungus, and shows that the *Gloeosporium* is but a conidial form of an ascigerous fungus

which develops on the dead leaves the following spring. In addition another conidial form grows on the branches, thus furnishing the spores by which the leaves are infected.

The form on twigs has been known as *Discula platani* (Sacc.); the spore-clusters are produced in small cavities situated under the lenticels. The spores are elliptical, hyaline, $8\text{-}12 \times 3\text{-}4{\cdot}5\ \mu$.

The form on living leaves, called *Gloeosporium nervisequum* (Sacc.), is the stage that does all the mischief; the spores are hyaline, narrowly club-shaped, $11\text{-}15 \times 4\text{-}6\ \mu$.

The highest or ascigerous stage of the fungus is called *Gnomonia veneta* (Kleb.). The perithecium is flask-shaped, sunk in the tissue of the leaf, the tip of the neck bursting through to the surface, asci clavate containing eight spores in two rows; spores elliptic-fusiform with a septum very near to one end, dividing the spore into two cells, one very large, the other minute, $12\text{-}16 \times 4\text{-}6\ \mu$.

Still another conidial form is described as occurring on the dead leaves. The reader is referred to the original account for full details.

This disease attacks the American plane (*Platanus occidentalis*), also *P. acerifolia*, commonly planted in England, and usually considered to be the Oriental plane, *P. orientalis*.

The spread of the disease can be checked in the case of nursery stock by spraying with Bordeaux mixture.

Klebahn, *Pringsh. Jahrb.*, 1905, p. 515.

Bird-cherry leaf blight.—The leaves of *Prunus avium*, the bird-cherry, are often attacked by a fungus, which until quite recently has been known as *Asteroma padi* (D. C.). Klebahn has proved, by means of pure cultures, that the above-named fungus is in reality only the conidial stage of an ascigerous fungus, *Gnomonia padicola* (Kleb.).

The conidial form of the fungus forms discoloured patches on the leaves, which in consequence fall quite early in the season; in instances where the attack is severe, the trees are often completely denuded of leaves by midsummer. Fortunately this disease has not as yet attacked the cultivated cherry.

In the *Asteroma* condition, the upper surface of infected leaves bear one or more patches of superficial, brownish mycelium, which radiates on all sides in irregular, fan-like

strands closely adpressed to the surface of the leaf. Nestling amongst this felt of mycelium are the numerous, very minute black perithecia, which contain small, hyaline, cylindrical conidia, $8\text{-}10 \times 1{\cdot}5\text{-}2\ \mu$. The ascospore form occurs on the dead leaves in the spring following their fall. Perithecia immersed, with a long, stout beak projecting from the under-surface of the dead leaf; asci $60\text{-}80 \times 5\text{-}6\ \mu$; 8-spored; spores hyaline, needle-shaped, often slightly bent, with one central septum, $43\text{-}54 \times 1\ \mu$.

Klebahn, *Zeitschr. Pflanzenkr.*, 18, p. 129 (1908).

Walnut leaf blotch.—Brown patches are not uncommon on living leaves of *Juglans regia*. Such spots, unless present in large numbers, do very little harm, but when an epidemic occurs the leaves fall early in the season. Until quite recently *Marssonia juglandis* (Sacc.), considered as an entity, was held responsible for the injury caused, but Klebahn has shown that *Marssonia* is only the conidial condition of an ascigerous fungus named *Gnomonia leptostyla* (Ces. and de Not.). The ascigerous form is produced on dead, fallen leaves in the spring.

Marssonia form. The conidial fruit forms small black specks situated on large brown or greyish-brown patches on the leaves. Conidia fusiform, usually curved, 1-septate, hyaline, $14\text{-}26 \times 2\text{-}3\ \mu$, springing from the tips of short conidiophores.

A second form of conidia are produced from the same spots; fusiform, hyaline, continuous, $6\text{-}12 \times 1\text{-}1{\cdot}5\ \mu$.

Ascigerous form. Perithecia globose, with a long, projecting beak; asci cylindric-clavate, 8-spored; spores cylindric-fusiform, hyaline, 1-septate, $19\text{-}25 \times 2{\cdot}5\text{-}3\ \mu$.

Spray with Bordeaux mixture when the leaves are young. Collect and burn fallen leaves.

Klebahn, *Zeitschr. Pflanzenkr.*, 17, p. 223 (1908).

VENTURIA. (De Not. and Ces.)

Perithecia subsuperficial, often setulose; asci 8-spored; paraphyses absent; spores elongated, uni-septate, yellowish.

Apple scab.—Undoubtedly the most injurious fungus attacking the apple-tree, in many instances rendering unsale-

able from half to the entire crop, in addition to the injury caused to the tree. It is present wherever the apple is grown, and until recently was supposed to be due to a fungus called *Fusicladium dendriticum* (Fuckel). The many researches of Aderhold on the Fusicladium of fruit-trees have clearly proved that the fungus concerned with apple scab is *Venturia inequalis*, Aderhold (=*Sphaerella inaequalis*, Cke.),

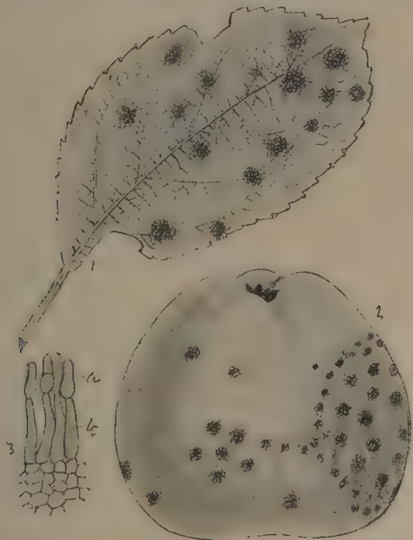

FIG. 57.—*Venturia inaequalis.* 1, conidial form of fungus on apple leaf; 2, conidial form of fungus on apple, causing scab; 3, fruit of conidial form of fungus, mag.

of which the *Fusicladium* is a conidial condition. It was at one time considered that the fungus was confined to the fruit, then it became known that it occurred on the leaves, at a still later period I announced its presence on the young shoots, since which time it has more than once been rediscovered on the twigs, and paraded as something new. On the twigs the fungus forms extended blackish-olive patches, at first covered by the epidermis or skin of the shoot, which eventually becomes ruptured and torn, or completely thrown

off. In early spring infected shoots are readily recognised by the much injured bark or skin which is frequently torn into shreds, more especially near the base of the last year's shoot. At this period of the year the exposed, blackish patches are densely covered with the *Fusicladium* form of fruit, which is carried by wind, rain, etc., on to the young leaves, which become infected. On the leaves the fungus first appears under the form of small, roundish, dark-coloured spots, mostly on the upper surface. These spots soon increase in size and run into each other, forming large, irregularly shaped, blackish-olive blotches, which under a pocket-lens present a dendritic or fibrous appearance towards the margin due to the extension of the blackish mycelium in the tissues of the leaf. At first the mycelium spreads in the leaf under the skin, which is eventually ruptured, exposing numerous *Fusicladium* conidia, similar to those produced on the year-old shoots. The conidia formed on the leaves, also from the shoots, are in turn conveyed to the young fruit, which becomes infected, and the result is *apple scab*. On the fruit the fungus forms the well-known, irregularly shaped, slightly sunken blackish patches or scabs, which under the pocket-lens presents the same dendritic or radiating appearance, as seen in the spots on the leaves. Some kinds of apple show gaping cracks when scabbed; this is because the outer portion of the fruit becomes rigid and unyielding under the influence of the fungus and ceases growing, hence the internal pressure causes the outer rigid portion to crack.

Ascigerous form. Perithecia globose with a short neck, 90-160 μ diam., with or without bristles above; asci 8-spored, 40-70 μ long; spores yellowish-green, unequally 2-celled, upper cell shorter and broader than lower, $11\text{-}15 \times 4\text{-}8$.

Conidial form. Effused, velvety, olive, forming dendritic patches, mycelium consisting of a compact mass of erect, closely septate brown hyphae; conidiophores closely septate, brown, $50\text{-}60 \times 4\text{-}6$, outline wavy or nodulose, conidia solitary, terminal, obclavate, yellowish-olive, for a long time continuous then 1-septate $30 \times 7\text{-}9\ \mu$.

Alderhold states that *V. inequalis* occurs not only on the apple (*Pyrus malus*) but also on allied species of *Pyrus*, excepting *P. communis*. A variety occurs on *Sorbus*, and probably on species of *Crataegus*. From the above account it will be seen that the young apples are mostly

infected by spores produced on the leaves. But the leaves could not become infected except by spores produced on diseased shoots, consequently diseased shoots are the source of all the mischief, hence the most natural thing to do under the circumstances is to remove and burn all such diseased shoots. This is what I have advocated, but I have been told by a professor of mycology and a professor of agriculture independently, and in public, that this is not

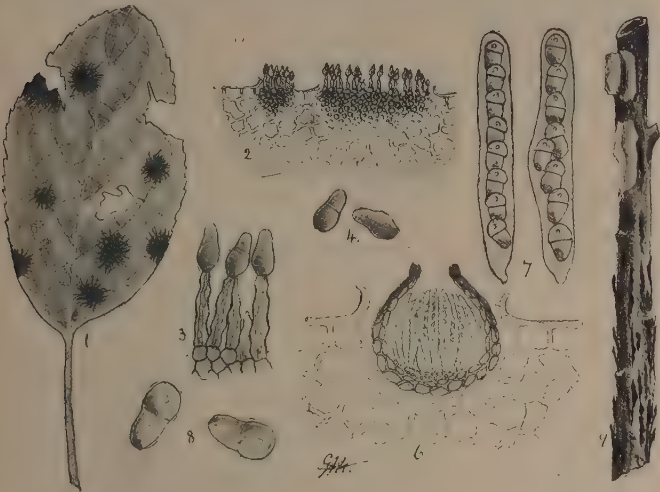

FIG. 58.—*Venturia inaequalis.* 1, conidial stage (*Fusicladium dendriticum*) on apple leaf; 2, 3 and 4, conidial stage; 6, section of perithecium (*Venturia* stage); 7 and 8, asci and spores of *Venturia*; 9, apple twig with *Fusicladium* stage, as appearing during winter and spring. Figs. 1 and 9 reduced; remainder highly mag.

practicable. I am not convinced. I believe that it is as practicable to remove the dead shoots from a tree as it is to remove the apples, in fact the Director of the Research Laboratory at Wisley informs me that, out of a batch of badly diseased apple-trees, those that had all diseased shoots removed, but not sprayed, produced a much cleaner crop of fruit than those that were persistently sprayed, but had not the diseased shoots removed.

Cut away all diseased shoots just below the point of the

previous year's growth, also older branches if showing the indications of disease described above. This work should be done during the winter. Just when the leaf-buds begin to swell, but before they expand, spray with full strength Bordeaux mixture. Spray again with half-strength Bordeaux mixture when the leaves are quite young, and repeat if the disease shows on the leaves. When the source of disease-infected shoots have once been removed, two sprayings, as indicated above, should be sufficient for the season, keeping an eye on the shoots, and remove diseased ones as they appear.

The cost of thoroughly overhauling the trees and removing all infected wood in the first instance, must be looked upon as an investment, which will return good interest if thoroughly done.

Diseased leaves and fruit should be either buried by turning the ground over during the winter, or collected and burned.

Aderhold, *Landw. Jahrb.*, 1896, p. 875.
Aderhold, *Centbl. f. Bakt. u. Par.*, 2, p. 593 (1900).
Aderhold, *Hedwigia*, 36, p. 67 (1897).
Goethe, *Gartenfl.*, May 15, 1887.

Pear scab, caused by *Venturia pirina* (Aderhold), closely resembles apple scab in general appearance, habit, sequence of development on twigs, leaves, and fruit, also in its botanical features. The fruit when attacked cracks much more frequently than in the case of apples. The disease is most prevalent during a cool, wet season.

Ascigerous form. Perithecia gregarious, mostly on the under surface of dead leaves that have been lying on the ground throughout the winter, 120-160 μ diam., with or without bristles; asci 8-spored; spores yellowish-green, unequally 2-celled, $14\text{-}20 \times 5\text{-}8$ μ.

Conidial form (*Fusicladium pirinum*, Fckl.). Effused, velvety, blackish-olive, conidiophores short, wall thick, outline wavy or knotted; conidia ovate-fusoid, olive, becoming 1-septate when old, $28\text{-}30 \times 7\text{-}9$ μ.

Preventive measures to be followed, same as those recommended for apple-scab.

Aderhold, *Centbl. f. Bakt. u. Par.*, 2, p. 593 (1900).

DIDYMELLA (Sacc.)

Perithecia immersed, membranaceous, asci 4-8-spored, paraphyses present; spores elongated, 1-septate, hyaline.
Differs from *Sphaerella* in having paraphyses.

Orange-tree canker (*Didymella citri.*, Noack) forms long canker-like wounds with thickened margins on the branches of orange-trees in Brazil. The first symptom of disease is the

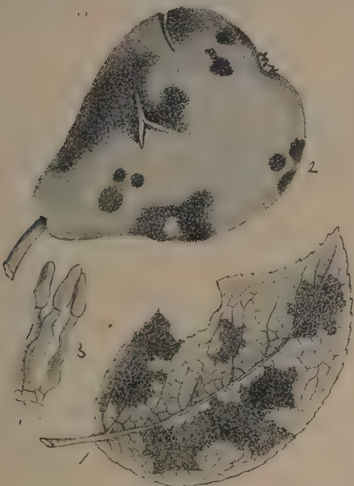

FIG. 59.—*Venturia pirina.* 1, conidial form of fungus on pear leaf; 2, conidial form of fungus on pear, causing scab; 3, fruit of conidial stage, highly mag.

shrinking and depression of a patch of bark, on which longitudinal and transverse cracks appear. When the wound becomes open, black pycnidia appear, followed by the ascigerous form of fruit.

Pycnidia very minute, 0·2-0·4 mm. diam., conidia colourless, fusiform, $7\text{-}9 \times 2\text{-}2{\cdot}5\ \mu$, on the tips of branched conidiophores.

Perithecia depressed globose, with a long, stout beak;

asci 8-spored, paraphyses slender; spores hyaline, 1-septate, $13 \cdot 5-18 \times 3 \cdot 5-4 \cdot 5$ μ.

Noack, F., *Zeitschr. Pflanzenkr.*, 10, p. 321 (1900). Several other diseases of the orange-tree are described in this article.

DIAPORTHE (Nits.)

Perithecia membranaceous or subcoriaceous, often greyish within, usually with a long, slender beak; asci fusoid, 8-spored; spores elongated, 1-septate, hyaline, with or without appendages.

Oak canker.—Oak-trees up to the age of about forty years are liable to this disease, caused by *Diaporthe taleola*, Sacc. (= *Aglaospora taleola*, Tul.) The disease is indicated by the presence of brown, dead patches of bark. As these patches are usually of large size, and scattered all round the trunk, the bark is killed, and the tree dies. Numerous black stromata are formed in the dead bark, which first bear conidia and afterwards the ascigerous fungus.

Stroma formed in the bark, perithecia numerous, crowded towards the centre, disc white; asci 8-spored; spores oblong-ovate, 1-septate, constricted, hyaline, with one slender appendage at each end, and three hair-like appendages springing from the median septum, $18-24 \times 7-9$ μ. Conidia hyaline, sickle-shaped.

Hartig suggests that when the disease appears in a wood, the younger diseased trees should be felled at once. This gives the remaining trees a better chance of recovery, and checks further infection.

Hartig, *Forstlich-naturwiss. Zeitschr.*, Jan. 1893.

American chestnut disease.—The native American chestnut (*Castanea dentata*) has been shown by Dr. Murrill to be subject to a very serious disease caused by *Diaporthe parasitica* (Murr.). It was at first supposed that the tree above mentioned was the only kind attacked, but it has now been discovered that other species of *Castanea*, both native and exotic, are also attacked. Infection takes place through wounds, and the fungus spreads beneath the cortex in the layers of inner bark and cambium, finally killing the bark,

which changes to a pale brown colour. At a later stage numerous fruiting pustules push through the lenticels, giving to the bark a rough, warty appearance. These represent the summer or conidial form of fruit, and liberate myriads of minute spores which ooze out in the form of tendrils, and are dispersed wholesale by various agents. At a later stage in the season winter spores are formed, which are disseminated from the dead branches the following season. Nursery stock and full-grown trees are equally attacked, and in most instances killed, as the disease usually girdles the trunk or branch attacked, thereby cutting off the supply of water and food.

Perithecia about twenty in a stroma, flask-shaped, neck long, asci 8-spored. Spores elliptic-oblong, hyaline, 1-septate, $9\text{-}10 \times 4\text{-}5\ \mu$. Summer spores, $2\text{-}3 \times 1\ \mu$, cylindrical, slightly curved, discharged in curly tendrils as in *Cytospora*.

Dr. Murrill considers this disease as of a very serious nature, and writes as follows: 'The chestnut growers of southern Europe should be warned against the importation of any species of *Castanea* from this country for public or private parks or plantations without inspection by a competent person. The European chestnut is so closely related to our native tree that the fungus would doubtless attack it with equal violence, causing great loss where it is cultivated.'

Murrill, W. A., *Journ. N.Y. Bot. Gard.*, 7, pp. 143, 203 (1906).

Murrill, W. A., *Torreya*, 6, p. 189 (1906).

PLOWRIGHTIA (Sacc.)

Stroma convex, black, the loculi or imperfect perithecia numerous, in a single peripheral row; asci 8-spored; spores elongated, 1-septate, hyaline, or yellowish.

Closely allied to *Dothidea*, from which it was separated by Saccardo, his distinction being—*Dothidea*, spores coloured; *Plowrightia*, spores hyaline. This distinction, however, is not a valid one, some species of *Dothidea*, representing one pole, have quite dark spores, others are only tinged with colour, whereas in *Plowrightia*, the other pole of *Dothidea*, the spores are either pale yellow or colourless.

Gooseberry black knot.—The fungus causing this disease

(*Plowrightia ribesia*, Sacc.) attacks the stem and larger branches of gooseberry, red and black currant, and is not uncommon in neglected gardens, more especially where aphides or currant scale are present. The fungus is a wound-parasite, and in all probability aphides or scale enable the parasite to gain an entrance into the living tissues of the host, as is known to be the case with apple-tree canker, larch canker, etc.

FIG. 60.—*Plowrightia ribesia*. 1, branch of gooseberry with black knot, nat. size; 2, black currant branch with black knot, nat. size; 3, section through a stroma, slightly mag; 4, asci containing spores, highly mag.

The first indication of disease is the wilting and yellowing of the foliage, which falls early in the season. As a rule a branch is not killed during the first year after infection; during the second season the leaf-buds remain only partially expanded, and the branch dies, owing to the ascent of water being cut off by the copious development of mycelium in the conducting vessels.

The fungus does not appear on the surface until the branch

is dead or nearly so, when numerous elongated, large black stromata or warts burst through the bark, always transversely to the long axis of the branch. These warts are often crowded, giving a blackened appearance to the branch.

Stromata black, minutely warted owing to the slightly projecting mouths of the loculi, which form a single crowded row at the periphery; asci 8-spored; spores elongato-fusiform, ends pointed, septum median, yellowish, 18-21 × 5-6 μ.

Fuckel considers that *Dothiorella ribis*, Sacc. (= *Podosporium ribis*, Fuckel) is a conidial condition of this species. Saccardo, on the other hand, says *D. ribis* is a condition of *Diaporthe strumella* (Fckl.), another ascigerous fungus growing on dead branches of gooseberries and currants. This point remains to be definitely settled. I have never found *Dothiorella* in Britain. It is characterised as follows: Perithecia few, immersed in a black stroma, which forms a prominent pustule; spores on short pedicels, ovate-oblong, often curved, hyaline, simple, 30 × 14 μ, expelled as a white mass.

Spraying is useless in the present instance. When the disease first appears, which is indicated by the wilting of the foliage, infected branches should be removed and burned. Aphides and currant scale should be kept down by the use of suitable spraying solutions.

Massee, G., *Gard. Chron.*

Black knot.—One of the most dangerous of diseases to which plum and cherry trees are subject is caused by a fungus called *Plowrightia morbosa* (Sacc.). This pest up to the present is confined to the United States and Canada, but there is the possibility of its introduction into Europe or other parts of the world at any moment.

The fungus forms large, nodulose, black excrescences on the branches, which are often bent or otherwise distorted at the point of injury. The excrescences often extend for several inches along the branch. A conidial condition of the fungus first appears bursting through cracks in the bark. This is followed by the growth of a swollen, irregularly nodulose, hard stroma, black externally, and minutely granular, due to the projecting mouths of the embedded perithecia.

Conidiophores forming a dense, blackish-olive, velvety pile;

conidia elliptical, olive, about 16 μ long. Pycnidia resembling the perithecia, containing elliptical pale yellow, 3-septate stylospores, $10\text{-}12 \times 6\text{-}7\ \mu$. Spermogonia also similar to the perithecia, producing very minute spermatia. Perithecia crowded, asci cylindric-ovate, $110\text{-}150 \times 16\text{-}18\ \mu$; spores

FIG. 61.—*Plowrightia morbosa.* 1, portion of a plum branch, showing conidial stage of the fungus; 2, branch with ascigerous condition of the fungus; 3, conidiophores bearing conidia; 4, ascus containing 8 spores. Figs. 1 and 2 reduced; rest highly mag.

obvate, hyaline, 1-septate, basal cell much the smaller of the two, $15\text{-}20 \times 8\text{-}10\ \mu$.

The only practical method of dealing with this disease is to cut out all diseased knots. When the tree is badly infected, new knots frequently develop at or near the points from which knots have been cut away. In such cases the

tree should be cut down and burned, as it never becomes free from the disease.

Farlow, G., *Bull. Bessay Inst.*, 1875.
Halsted, *New Jersey Agric. Coll. Expt. Station*, *Bull.* 78.

MYCOSPHAERELLA (Johans.)

Perithecia as in *Sphaerella*, asci 16-spored, without paraphyses; spores elongated, 1-septate, hyaline.

Pear leaf spot.—The early defoliation of pear-trees has for long been considered to be due to the presence of a fungus called *Septoria piricola* (Desm.). This has recently been

Fig. 62.—*Mycosphaerella sentina.* 1, pear leaf attacked by fungus, nat. size; 2, conidia of *Septoria* form; 3, ascus and free spores of ascigerous form. 2 and 3 highly mag.

proved by Klebahn to be the conidial condition of the ascigerous fungus, *Mycosphaerella sentina* (Schröter). The injury is undoubtedly caused by the conidial form of the fungus, the ascigerous condition developing only on dead leaves that have been lying on the ground throughout the winter.

The *Septoria* usually forms many rather small, irregularly rounded spots on the living leaves, these become dry and greyish, surrounded by a brown border, and are most conspicuous on the upper surface of the leaf. The perithecia, resembling minute black dots, are thinly scattered over the diseased spots on the under side of the leaf.

Perithecia of conidial form, globose, sunk in the tissues of the leaf; conidia long and slender, slightly curved, 3-celled, hyaline, escaping from the perithecium in the form of a viscid tendril, $60 \times 3\text{-}4$ μ.

Perithecia of ascigerous form are globose and immersed, with a short, slightly projecting mouth. Asci $60\text{-}75 \times 11\text{-}13$ μ, 8-spored; spores hyaline, very slightly curved, fusiform, 1-septate, $26\text{-}33 \times 4$ μ.

Spray with half strength Bordeaux mixture, beginning when the foliage is quite young. Diseased, fallen leaves should be destroyed.

Klebahn, *Zeit. Pflanzenkr.*, 18, p. 5 (1908).

Elm leaf spot.—Numerous small brown spots appear on the under surface of the leaves, which in consequence gradually turn yellow and fall early in the season. The minute spores ooze to the surface of the leaf in white, viscid tendrils, and if not washed off by rain, adhere to the surface of the leaf, which is then sprinkled with minute whitish patches. Until recently it was supposed that this disease was entirely due to *Phleospora ulmi*, Wallr. (at one time *Septoria ulmi*, Fr.), whose spore-clusters are produced in the tissue of the leaf underlying the brown spots. The spores are narrowly fusiform, slightly curved, 2-4-septate, $25\text{-}50 \times 4\text{-}7$ μ. Quite recently, however, Klebahn has shown that *Phleospora* is only a conidial form of an ascigerous fungus, called *Mycosphaerella ulmi* (Klebahn). This stage of the fungus develops on dead leaves in the spring; the flask-shaped perithecia are embedded in the tissue of the leaf. The asci contains eight spores in two rows. Spores hyaline, 1-septate, subfusiform, $22\text{-}27 \times 4\text{-}5$ μ.

Parasitic on *Ulmus campestris* and other species of *Ulmus*.

Nursery stock and young trees suffer most from this disease. Spray with Bordeaux mixture, and collect and burn fallen leaves.

Klebahn, *Pringsh. Jahrb.*, 1905, p. 485.

Cucumber and tomato canker.—Dr. Grossenbacher has recently described a disease caused by *Mycosphaerella citrullina* (Grossenb.), which has proved destructive to melons in the United States. The presence of the disease is indicated by the wilting of the leaves first, then the entire plant. The nodes of the skin, especially those on the lower part of the plant, are of a waterlogged or oily-green colour, with or without an exudation of gum. At a later stage these diseased patches become dark and gummy, or dry and grey, depending upon the quantity of gum present. Most infections are confined to the nodes, and when the patches have been in existence for some time, numerous minute blackish perithecia are present. Infection experiments proved that the parasite can enter uninjured tissues of melon plants. Pumpkins or vegetable marrows, water-melons, and certain other cucurbitaceous plants were also proved to be susceptible to the disease, but curiously enough cucumber plants proved quite immune, and resisted all attempts at infection. Two forms of fruit are produced by the fungus; first a conidial form, known as *Diplodina citrullina* (Grossenb.), and as *Ascochyta citrullina* (C. O. Smith). This is followed by the ascigerous form of fruit, *Mycosphaerella citrullina* (Grossenbacher).

During the early summer of 1909 I received several independent consignments of diseased tomato plants from the neighbourhood of Waltham Cross, Mx., showing in every case a canker-like disease attacking the basal portion of the stem, for a distance of two to four inches in length, commencing from the ground line. The lower nodes of the stem also sometimes showed diseased pale spots. The diseased portion of the stem was shrunken and the cortex considerably broken up by the mycelium of the fungus present, which proved on examination to be the *Ascochyta*, or conidial form of the fungus, causing melon wilt. The minute perithecia of the fungus were very abundant on the broken up tissues of the stem, and were present even for some distance on the underground portions. Tomato plants attacked as described above soon wilt and die. Within a week after the receipt of the diseased tomato plants, a specimen of a diseased cucumber plant was received at Kew for examination from Gloucestershire, which showed the characteristic whitish blotches at the nodes of the stem, described and depicted as attacking melon plants in the United States, and on examining the fungus,

which was present in abundance in the friable, whitish, broken up epidermis, it again proved to be the *Ascochyta* or conidial form of *Mycosphaerella citrullina*. Experiments conducted at Kew proved that the fungus developed on cucumber plants would infect young tomato plants, and that spores from diseased tomato plants would infect vegetable marrows. In both cases the plants infected produced the conidial form of the fungus within a fortnight, and in both instances the lesions formed were characteristic. The ascigerous condition of the fungus has not been observed at Kew.

Can this, like the A. M. G., or so-called American gooseberry mildew, be considered as another affliction imported from America? This I consider to be doubtful. Melon, cucumber, and tomato plants do not come to us from the United States in a growing condition, if they come at all, and probably the fungus is with us under some other name, but I have not before observed it as a destructive parasite, neither have I seen it described as such. The fungus does not attack the fruit.

Ascochyta form. Perithecia depressed globose, with a minute apical pore, parenchymatous, wall thin, pale brown, 90-150 μ. diam., crowded; conidia hyaline, oblong, ends rounded, becoming 1-septate, usually constricted in the middle or slightly dumbbell-shaped, averaging 14×4-5 μ.

Ascigerous form. Perithecia roughish, dark brown to black, depressed globose, ostiolum slightly prominent, erumpent, and finally almost superficial, densely scattered, 100×165 μ; asci cylindric-clavate, spores 1-septate, hyaline, elliptic-oblong, slightly constricted at the middle, distal cell often largest.

This fungus appears to be in the wrong genus. I leave the rectification to the author.

The disease is evidently a deadly one; a grower stated that 'the plants fall over like ninepins, nine or ten a day.' The only thing to do is to remove and burn infected plants on the first sign of the disease, as apparently when once attacked recovery is impossible. Spray remaining plants, also the soil, with Bordeaux mixture.

Grossenbacher, J. G., *N.Y. Agric. Expt. Sta., Geneva, N.Y., Technical Bull.* No. 9 (1909).

C. *Spores hyaline. More than 1-septate*

CALOSPORA (Sacc.)

Stroma sunk in the host, pustulate; asci normally 8-spored; spores elongated, 2-many-septate, hyaline, with or without appendages; paraphyses present.

Vanilla disease.—A consignment of diseased vanilla plants (*Vanilla planifolia*, Andr.) was received at Kew for examination, accompanied by a report stating that the vanilla industry in the Seychelles was threatened, owing to the somewhat sudden and widespread occurrence of a disease suspected to be due to a fungus. Examination showed that the disease was in reality caused by a fungus, which being undescribed, was called *Calospora vanillae* (Mass.). A conidial condition of the fungus, agreeing in character with the form-genus (*Hainesia*), formed minute, dull-red or amber-coloured, subtremelloid specks in groups, on slightly discoloured patches on the living leaves and stem. A second conidial stage followed on the same spots, and finally when the host was quite dead, the ascigerous condition appeared.

The same fungus, showing all three stages of fruit, was sent to Kew at a later date, from Antigua and New Granada, attacking the same species of vanilla.

Hainesia form. Dull red or amber-coloured, gelatinous specks, conidia almost hyaline, continuous, $9\text{-}10 \times 3\text{-}5\text{-}4\ \mu$.

Cytospora form. Perithecia globose, conidia hyaline, elliptical, continuous, $14\text{-}16 \times 6\text{-}7\ \mu$.

Ascigerous form. Perithecia subglobose, narrowed above into a neck, asci cylindric-clavate, $90\text{-}100 \times 12\text{-}14\ \mu$, 8-spored, spores elliptical, 3-septate, hyaline, $15\text{-}16 \times 5\ \mu$, paraphyses slender.

Clearing away and burning all diseased plants, which had been allowed to lie and rot on the ground, suppressed the disease, which was stated to be most prevalent in low, badly drained districts.

Massee, *Kew Bull.*, June 1892.

SPHAERULINA (Sacc.)

Perithecia immersed, spores escaping through a short protruding mouth. Asci 8-spored, paraphyses absent. Spores elongated, hyaline, 3-many-septate.

Differs from *Sphaerella* in the spores being more than 1-septate, and from *Leptosphaerella* in the absence of paraphyses.

The majority of species occur on fallen leaves and are considered as saprophytes, but nothing certain is known of the life-history of most forms.

Yew leaf scorch (*Sphaerulina taxi*, Massee) is at times the cause of serious damage to yews. The leaves are attacked, the first indication of mischief being a change from the normal dark green to a brown colour. At a later stage the upper surface of the leaf is densely studded with minute pustules or warts, corresponding to the embedded perithecia, the mouth alone protruding through the ruptured epidermis. As a rule when this parasite once attacks a tree it spreads very rapidly, so that within a short period of time all the leaves have fallen; many of the younger shoots are also killed and fall to the ground.

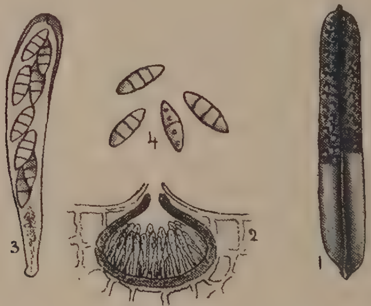

FIG. 63.—1, *Sphaerulina taxi*, on yew leaf, slightly mag.; 2, section of perithecium, slightly mag.; 3, ascus containing spores, highly mag.; 4, free ascospores, highly mag.

If the disease attacks a tree for two or three years in succession it is usually killed outright.

Fortunately this is not a common disease, or at all events it is not very frequently recorded. I have seen it at work in Cornwall, and also in Yorkshire, where a number of fine yew-trees growing in a churchyard were being killed. Mr. F. Moore of Glasnevin informed me that he had noticed the disease in three counties in Ireland.

Perithecia immersed in the matrix; asci elongato-clavate, apex thickened, $65 \times 75 \times 12\text{-}14$ μ; spores narrowly elliptical, ends rather acute, hyaline, for a long time 1-septate, finally 3-septate, $16\text{-}22 \times 5$ μ.

So far as I am aware no preventive methods have been tried. Probably Bordeaux mixture would save healthy leaves and shoots from being infected. Certainly all fallen leaves and twigs that are diseased should be swept up and burned.

Sphaerulina intermixta (Sacc.) occurs on living stems of bramble and wild rose, and may, possibly, pass on to cultivated forms.

Perithecia gregarious, minute, under the epidermis, 80-100 μ diam.; asci clavate, apex thickened, $45\text{-}55 \times 12\text{-}14$ μ, 8-spored. Spores elongato-clavate, 3-4-septate, hyaline, $16\text{-}18 \times 6\text{-}8$ μ.

Sphaerulina myriadea (Sacc.) Perithecia crowded, forming vague patches on fallen leaves of oak and beech, 90-100 μ diam. Asci subfusoid, 8-spored. Spores elongated, both ends rather acute, 3-septate, hyaline, $30\text{-}35 \times 2\text{-}3$ μ.

ACANTHOSTIGMA (De Not.)

Perithecia free, globose, fragile, hairy, papillate; asci 8-spored; spores elongate-fusoid, 1-5-septate, hyaline.

Silver fir leaf disease (*Acanthostigma parasiticum*, Sacc. = *Trichosphaeria parasitica*, Hartig) is abundant in fir woods, attacking more especially the silver fir, less frequently the spruce. The mycelium is white at first, then yellowish-brown, and covers the under surface of the leaves. The leaves are first killed but do not fall, being fixed to the branch by cobweb-like mycelium. At a later stage the branches are also killed. In crowded woods the fungus passes quickly from tree to tree, and does a considerable amount of injury.

Perithecia minute, mouth distinct, upper portion with rigid, spreading bristles; asci 8-spored; spores elongate-fusoid, smoky-grey, 2-3-septate, 15-20 μ long. Most abundant in damp localities and where the trees are crowded. In dry, airy districts the fungus does but little harm.

Hartig, *Alleg. Forst. u Jagd. Zeit.*, Jan. 1884.
Prillieux, *Malad. des Plantes Agric.*, 2, p. 208 (1897).

HERPOTRICHA (Fckl.)

Perithecia carbonaceous, globose, clothed with long, crisped, creeping hairs, apex almost glabrous; asci 8-spored; spores hyaline, many septate; paraphyses present.

Pine leaf fungus (*Herpotricha nigra*, Hartig) is very destructive to young larches in elevated regions; it also attacks *Abies excelsa*, *Juniperus communis*, and *J. nanus*. The brown mycelium envelops branches and even whole trees in a dense weft. The lower branches are often anchored to the ground by the mycelium. After the leaves are killed they do not fall, but remain fixed to the branch by mycelium. The dead leaves also become covered with a weft that bears the perithecia.

Perithecia subglobose, black, with long deflexed hairs near the base; spores 1- soon 3-septate, constricted at the middle.

The fungus is met with in upland regions more especially, and grows vigorously under the snow. Nurseries should not be formed at high elevations, nor in valleys where the snow lies for a long time.

Hartig, *Alleg. Forst. u. Jagd. Zeit.*, 1888.
Prillieux, *Malad. des Plantes Agric.*, 2, p. 212 (1897).

CLAVICEPS (Tul.)

Stroma stipitate, capitate, springing from a sclerotium; perithecia immersed in the capitate stroma; asci 8-spored; spores needle-shaped, septate. Spormogonia and conidia present in some species starts the disease anew.

Apart from the loss occasioned by the fungus, its action on animal life is very serious. Rye bread, containing much ergot, is the cause of a terrible malady characterised by gangrene of the extremities. Abortion is also caused by partaking of sclerotia along with food. A serious epidemic of cattle in the United States, at first supposed to be the dreaded 'foot-and-mouth disease,' was proved to be caused by ergotised food.

The most certain method of checking the disease is to collect the sclerotia, which can be sold for medicinal purposes. In the case of grass, cutting before the sclerotia are ripe also arrests the disease.

Tulasne, *Ann. Sci. Nat.*, Ser. 3, 20, p. 5.

Ergot.—This well-known disease, caused by *Claviceps purpurea* (Tul.), is often developed in the ears of various

FIG. 64.—*Claviceps purpurea.* 1, ergot on rye-grass; 2, ergot on rye; 3, section of portion of conidial fruit; 4, sclerotium or ergot bearing the stalked, ascigerous form of fruit; 5, head of ascigerous fruit showing warted surface, due to projecting mouths of perithecia; the section shows perithecia sunk in the fleshy stroma; 6, ascus; 7, free needle-shaped spore. Figs. 1, 2 and 4 nat. size; remainder variously mag.

cereals, especially rye, also in the inflorescence of many kinds of grasses. Infection takes place when the plants are in bloom, the mycelium developing in the ovary, replacing the

seed. A whitish stroma forms over the ovary, which bears very minute conidia, which are mixed with a sweet liquid that attracts insects, by whom the conidia are carried from one flower to another. As the conidia germinate at once, many flowers become infected. After the conidia are dispersed the stroma grows into a purplish-black, horn-shaped body or sclerotium, known as ergot. These fall to the ground and remain until the following spring, when they give origin to the stalked ascospore stage, the spores of which are dispersed by wind.

EPICHLOE (FRIES.)

Stroma sessile, effused, girdling the leaf sheaths of grasses, bright-coloured, at first bearing conidia; perithecia immersed, asci 8-spored; spores needle-shaped, septate.

Reed-mace fungus.—This very peculiar fungus, called *Epichloe typhina* (Tul.), attacks most kinds of grass, which it strangles, and produces an appearance resembling the inflorescence of a reed-mace or a bulrush. The sheath of the upper leaf is attacked and becomes surrounded by a crust or stroma half an inch to an inch in length. This stroma is white at first, and at this stage produces myriads of conidia which germinate at the moment of maturity, and thus ensure the rapid spread of the disease, which frequently assumes the proportions of an epidemic. At a later stage the stroma changes to a deep orange colour, and an ascigerous form of fruit replaces the conidial condition, the surface of the stroma becoming rough with the projecting mouths of the perithecia. Plants that are attacked do not bloom, the inflorescence being arrested and remaining enclosed in the sheath. According to Prillieux when hay containing a considerable amount of diseased grass is eaten by horses, it proves injurious and causes coughing.

Stroma entirely encircling the culm of various grasses, 1-3 cm. long, at first whitish and bearing minute, hyaline, oval conidia, $4 \cdot 5 \times 3$ μ. The stroma then becomes tawny orange, minutely granular from the projecting mouths of the perithecia; asci cylindrical, slightly constricted below the truncate apex, $130\text{-}200 \times 7\text{-}10$ μ; spores filiform, hyaline, very delicately multi-septate, $130\text{-}150 \times 1\text{-}1 \cdot 5$ μ, arranged in a parallel bundle in the ascus.

A disease that is exceedingly difficult to deal with, as it is so generally distributed on grasses throughout the country, and when in abundance causes loss on account of the inflorescence being arrested. I have seen many acres of *Agrostis canina* (L.) growing on a common, practically every

FIG. 65.—*Epichloe typhina*. 1, fungus or leaf-sheath of *Holcus mollis*; 2, fungus on *Holcus lanatus*; 3, portion of fungus showing warts on surface, corresponding to mouths of perithecia; 4, section of perithecium; 5, ascus with spores escaping; 6, ascospore; 7, conidiophores with conidia. Figs. 1 and 2 reduced; remainder mag.

plant of which was infected. It is often abundant on wild grasses growing on the borders of fields, etc.

The only preventive method that can be suggested is that of cutting the grass before the fungus becomes orange in

colour, and produces the winter form of fruit, as this is what sets up the infection in the spring.

Prillieux, *Malad. des Plantes Agric.*, 2, p. 96 (1897).
Tulasne, *Fung. Sel. Carp.*, 3, p. 24.

OPHIOBOLUS (Reiss.)

Perithecia scattered, submembranaceous, asci cylindrical, typically 8-spored; spores needle-shaped, septate or guttulate, hyaline.

Very minute fungi, growing on culms, stems, etc.

'Take-all' and 'White-heads' in wheat (Fig. along with *Gibellina cerealis*, see p. 242).—These names, according to M'Alpine, are used in Australia to describe the serious inroads made by a fungus called *Ophiobolus graminis* (Sacc.) on the wheat crop during different stages of growth. The disease is equally well known in some parts of Europe, and is called 'Maladie du pied,' 'Piétin du Blé,' 'Foot-rot,' 'Black-leg,' etc. In England it is known as 'Straw blight.' The Australian names are very expressive, and are used here. The 'take-all' symptoms are the presence of stripes or patches where the wheat plants appear to have been checked in their growth, dying off while young, so that nothing remains but dead, shrivelled plants. The 'white-head' condition does not show until the ears are fully formed, but remain 'deaf,' the grain not developing, and on examination not only are the ears found to be bleached and dead, but also the entire plant down to the ground. These two marked symptoms were at one time considered as distinct diseases; both, however, are now known to be caused by the same fungus, and careful examination shows that wheat plants succumb at all stages of development. Broadly speaking, when the plants are attacked when quite young, the 'take-all' stage predominates, whereas when the plants are infected at a much later stage, the 'white-head' appearance predominates. The root and base of the culm are the parts attacked.

The vegetative portion of the mycelium penetrates the tissues of the lower internodes of the culm and of the root, which become brown and dead. A brown superficial mycelium is also formed on the surface of the culm and on the inside of the leaf-sheaths, which becomes compact,

forming a weft that can be peeled off. On this felt, and on adjoining portions of the dead sheaths of the leaves, the perithecia are produced, resembling black points. These fruits are produced on the dead plants and stubble during the winter months.

Perithecia black, globose, with a conical, curved beak. Asci clavate, apex rounded, containing eight needle-shaped, slightly curved, 3-septate, hyaline spores, $70\text{-}75 \times 3\text{-}4\ \mu$, arranged in a parallel fascicle in the ascus.

The fungus occurs on wild grasses; it has been met with on species of *Agropyron* in Italy, and on *Bromus sterilis* in Australia. The suggestion is that the stubble of diseased patches should be burned, but I do not know how far it is really practicable. Red wheats are said to be most resistant. A dressing of Thomas's phosphate and subsequent rolling, also 70 lbs. sulphate of iron per acre is recommended. M'Alpine says that oats are not attacked, and may with safety follow a diseased crop of wheat.

M'Alpine, *Depart. Agric. Vict.*, *Bull.* No. 9 (1904).
Prillieux and Delacroix, *Bull. Soc. Myc. France*, 6 (1890).
Prillieux, *Malad. des Plantes Agric.*, 2, p. 221 (1897).

Ophiobolus herpotrichus (Sacc.). Cugini has described a disease of wheat caused by the above fungus, which presents the same general appearance, and produces the same effects as those caused by *O. graminis*. This disease is confined to Italy.

Perithecia conico-globose with a small papilla at the apex. Asci containing eight needle-shaped spores, $135\text{-}150 \times 2\text{-}2{\cdot}5\ \mu$.

Cugini, *Giorn. Agrar. Ital.*, 14 (1880).
Cugini, *Bol. Staz. Agrar. Modena*, 9, p. 46 (1890).

D. *Spores coloured, continuous.*

NEOCOSMOPARA (E. F. Smith)

Perithecia as in *Nectria*. Asci cylindrical, spores 8, uniseriate, globose or subglobose, brown.

Conidial forms are known.

Wilt disease of Cotton, Water-melon, and Cowpea.—Dr. Erwin F. Smith has described a disease of cotton (*Gossypium herbaceum* and *G. Barbadense*), water-melon (*Citrullus vulgaris*), and on cowpea (*Vigna sinensis*), caused by a very remarkable and novel type of fungus, which he has named *Neocosmopora vasinfecta*. The fungus lives from year to year in the ground, and infection always takes place underground. The mycelium forms dense masses in the water ducts, and afterwards invading the parenchyma, by this means the plant is deprived of water and food supplied by the root, and the plant exhibits the disease known as 'wilt' or 'blight.' In this way whole fields of melon and cotton plants are destroyed. The fungus has two conidial forms of fruit. Microconidia produced in the interior of the plant before it is dead. Macroconidia formed on the surface of the host after it has been killed. Ascigerous form of fruit, on dead roots, rarely on the parts above ground.

Ascigerous stage. Perithecia gregarious, ovate; red, resembling those of a *Nectria*. Asci cylindrical, containing 8 uniseriate spores; spores globose or broadly elliptical, at maturity light brown, epispore thickish, wrinkled, 10-12 μ diam., or 8-12 $\times$ 11-14 μ.

Microconidia. Produced on the ends of short branches of mycelium in the water ducts and living parts of the stem; elliptical, continuous, hyaline, 4-25 $\times$ 2-6 μ.

Macroconidia (Fusarium stage). Lunulate, 3-5-septate, 30-50 $\times$ 4-6 μ. On surface of dead stems on sporodochia, which are pinkish or salmon colour.

A difficult disease to combat, as the infection is in the soil; as every diseased plant has numerous spores in and on its substance, unless these are destroyed the disease is certain to be conveyed from one place to another.

Smith, Erwin F., *U.S. Dept. Agric.*, *Division Veg. Physiol. and Pathol.*, *Bull.* No. 17 (1899).

ROSELLINIA (De Not.)

Perithecia almost superficial, subglobose, papillate, subcarbonaceous, black, glabrous or hairy, or seated on a velvety byssus; asci 8-spored; spores continuous, broadly ovate or elongated and cymbiform, brown, with or without hyaline appendages; paraphyses present.

FIG. 66.—*Rosellinia necatrix*. 1, portion of root of apple-tree with white fleecy mycelium; 2, brown hyphae with swellings; 3, root with sclerotia bearing conidial fruit; 4, single cluster of conidiophores; 5, branch of last bearing conidia; 6, stylospores produced in pycnidia (after Viala); 7, perithecium surrounded by conidiophores (after Viala); 8, ascospores; 9, a sycamore infected with the fungus, the portion above ground enveloped in white mycelium, the portion below ground with numerous sclerotia, *c* (after Hartig). Figs. 1 and 9 reduced; the remainder variously mag.

White root rot.—This disease is very prevalent in vineyards, orchards, etc., on the Continent, but is fortunately somewhat rare in this country. It is caused by *Rosellinia necatrix*, Prill. and Del. (= *Dematophora necatrix*, Hedwig). One of the marked peculiarities of this pest is its power of becoming parasitic on a great variety of plants belonging to widely separated Orders; in fact, it may be stated broadly that it attacks every plant with which it comes in contact.

Hartig enumerates the following as having been destroyed by the fungus: vines, fruit-trees, potatoes, beans, beet, young maples, oaks, beeches, pines and spruces. As in *Armillaria mellea*, the mycelium of the fungus under consideration travels underground, and when it comes in contact with the rootlets of a plant it kills them, and gradually works its way into the tissues of the larger branches of the root. In the case of large plants, the mycelium, after travelling along the tissues of the root up to the base of the trunk, bursts through the cortex in the form of a snow-white, fluffy mycelium, which again traverses the ground and spreads until it comes in contact with another root. During the progress of the disease numerous minute sclerotia are formed, in the cortex of the diseased roots; and if such roots happen to be exposed to the air, these sclerotia burst through the bark and give origin to groups of minute bristle-like, dark-coloured conidiophores which bear numerous conidia at their tufted tips.

A second kind of fructification sometimes occurs on decaying roots, under the form of minute black conceptacles, or pycnidia. As previously stated, the mycelium is at first snow-white, but the older and exposed portions soon change to a smoky brown colour, and develop pear-shaped swellings at intervals throughout their length. According to Viala these swellings under certain conditions gradually become globose, and are capable of emitting mycelium which forms a new plant.

The highest or ascigerous stage of fruit has been discovered by Viala, appearing only on trees that have been dead for a long time and much decayed.

Owing to the subterranean habit of the fungus, spraying is out of the question, as is also a cure when the mycelium is once established in the roots. The soil should be well drained, as the fungus thrives best in sodden soil. If the disease appears, affected plants should be isolated by digging

a narrow trench about a foot deep round the trunk, at such a distance as to include the main roots, and if the roots are cut through they should be followed and removed. All the removed soil should be thrown inside the trench. Trees that have been killed should be removed, and special care should be exercised in removing the stumps to get all roots possible, as if these are allowed to remain they will form centres of infection from which the mycelium will rapidly spread. Weeds growing near infected plants should also be removed and burned. A method that has proved beneficial in France is to expose the base of the trunk as far down as possible, and to powder both trunk and surrounding soil liberally with powdered sulphur.

Hartig, *Unters. Forstbot. Inst. München*, 3, p. 95.
Viala, *Mon. du Pourridié des Vignes et des Arbres fruitiers*, 5 pl.

New Zealand white root rot.—This destructive disease is caused by *Rosellinia radiciperda* (Mass.), which is closely allied to the fungus causing white root-rot in Europe—*Rosellinia necatrix*. Mr. Allan Wright of New Zealand describes its ravages as follows:—'This fungus in the mycelial stage attacks a great variety of tree roots, amongst the most conspicuous of which are the apple, pear, peach, and all other common orchard trees. The white thorn is also very subject to its attacks, as well as a great many *Abies*, and several of the native trees and plants. It also attacks the cabbage, the potato, docks, sorrel, fern, and in fact is almost omnivorous. Its movements are uncertain; sometimes a tree here and there dies, sometimes a whole row, and very often acres are swept off.'

The bark just underground, or the roots, are first attacked, and presently a delicate white mycelium is seen on the surface of diseased parts. This mycelium forms white strands which run a few inches underground until another victim is reached. As the disease progresses, numerous minute black sclerotia, which eventually give origin to a conidial form of fruit, are formed in the cortex of diseased portions. Next, the mycelium becomes dark-coloured and gives origin to globose, black bodies, called pycnidia, containing stylospores. Finally the ascigerous form of fruit is produced on trunks or stumps that have been dead for some time.

The same or a closely allied form of root-rot appears as a

FIG. 67.—*Rosellinia radiciperda.* 1, ascigerous condition; 2, perithecia; 3, section of same; 4, ascus containing 8 spores, also two paraphyses; 5, tip of an ascus after treatment with iodine, showing the arrangement for effecting the opening of the ascus for escape of spores; 6, ascospores, one germinating; 7, brown mycelium with swellings; 8, black sclerotium bearing a cluster of conidial fruit; 9, a single conidiophore; 10, conidia; 11, pycnidium; 12, stylospores from same. (From *Kew Bulletin.*) Fig. 1 nat. size; remainder variously mag.

sort of natural sequence to planting on forest ground, judging from material received at Kew from various parts of the world. Wherever tree-stumps remain in the ground, the mycelium spread from thence, and naturally attacks young, growing roots. As the land becomes better cultivated this pest gradually disappears, but not as a rule before early crops have suffered. Kainit or sulphate of potash pricked into the soil checks the underground spread of mycelium.

Ascophores densely gregarious, seated on a black, velvety mass, glabrous, mammilate; asci cylindrical, 8-spored; spores elliptic-fusiform, slightly inaequilateral, continuous, brown, $40\text{-}45 \times 12\ \mu$. Pycnidia subglobose, black, sparingly pilose, stylospores elliptic-oblong, continuous; hyaline, $7\text{-}8 \times 4\text{-}5\ \mu$.

Conidiophores springing from black sclerotia, much branched at apex, conidia hyaline, continuous, elliptic-oblong, $7 \times 4\ \mu$.

Stagnant water should not be allowed to remain in the soil, as this favours the spread of the fungus. In cases where the fungus has devastated large areas, it is probable that such will be deserted as unprofitable, the tree being allowed to lie and rot, and the fungus to spread in the soil. This is disastrous, being in fact a nursery for the development and diffusion of the enemy. It is not our object to suggest whose business it is to prevent such short-sightedness, but to impress emphatically that such a condition of things should not be tolerated.

Massee, *Kew Bulletin*, 1896, p. 1.
Wight, *Journ. Mycol.*, 5, p. 199.

Seedling oak disease.—Hartig has given a very exhaustive account of a disease attacking the roots of seedling oaks. In seed-beds where the plants from one to three years of age are placed in close proximity to each other, and their roots become intermixed, *Rosellinia quercina* (Hartig), the fungus causing the disease, spreads rapidly in the ground from one plant to another, by means of Rhizoctonia-like mycelium. At times when the temperature is high and moisture present, the disease quickly spreads through an entire bed of seedlings. The first indication of injury is the wilting and drying up of the leaves, the uppermost ones first showing these symptoms, the lower leaves dying in turn, after which the seedling perishes. When the root of a plant that

has been killed by the fungus is examined, its surface is found to be more or less covered with fine thread-like strands of white mycelium. When the root is in the ground, these strands of mycelium spread on the surface of the ground during damp weather, and change to a brown colour. Numerous minute blackish sclerotia are also formed on the surface of the dead root. These strands of mycelium traversing the ground penetrate very readily the tissues of young rootlets not yet protected by a layer of periderm, and enter all the tissues, and in less than fifteen days a root thus attacked has all its wood completely destroyed, a hollow tube formed by the bark alone remaining. During this process of destruction compact masses of mycelium resembling flattened sclerotia are formed in the bark. At a later stage these sclerotia give origin to strands of mycelium which radiate in every direction in the soil. Conidial fructification is produced on the mycelium surrounding the collar of the stem and adjoining soil. The conidiophores are slender, hyaline, erect, and bear two or three whorls of short branchlets near the apex. Each branchlet bears at its apex a minute, shortly cylindrical, hyaline conidium. At a later date the ascigerous form of fruit is produced on a dense weft of mycelium covering the base of the stem and superficial roots, and on strands of mycelium on the ground.

Ascigerous form. Perithecia scattered or subgregarious, seated on blackish mycelium, black, globose with a minute papilla or mouth, about 1 mm. diam.; asci subcylindrical, 8-spored, $160\text{-}170 \times 8\text{-}10\ \mu$; spores obliquely 1-seriate at first, fusoid, guttulate, both ends rather acute, brown, $28 \times 6\text{-}7\ \mu$.

The disease appears to be confined to young trees in the nursery ground. When it appears at a given point it rapidly spreads by means of its underground strands of mycelium.

Seedlings that are attacked should be removed, and an open trench made at some distance from the centre of disease, to check its extension. The fungus is very impatient of moisture; plenty of air and good drainage are essential.

Hartig, *Unters. aus d. Forstbot. zu München*, 1880.

Hartig and Somerville, *Diseases of Trees* (Engl. ed.), p. 78 (1894).

Mulberry root rot (*Rosellinia aquila*, De Not.) is frequently the cause of serious injury to the mulberry-tree, which as a rule results in the death of the tree attacked.

Various other kinds of trees are also injured by this parasite. The mycelium at first forms thin white patches on the bark of the root; these patches gradually extend over the surface of the root and form crust-like stromata, black externally, whitish inside. At this period the mycelium forms strands, and changes in colour to a dark brown. The mycelium penetrates every portion of the root, being most abundant in the medullary rays. When the black crust-like patches or stromata are fully formed, the vegetative activity of the parasite is arrested, and the production of productive bodies begins.

During a continued period of dampness, the surface of the black stromata becomes covered with a delicately velvety, olive growth consisting of densely packed conidiophores. As development proceeds the velvety pile changes to a grey colour, due to the growth of hyaline branched tips to the conidiophores. These hyaline tips are irregularly branched, each branchlet bearing several elliptical, almost hyaline conidia, $7\text{-}10 \times 6\text{-}7\ \mu$. This conidial form of the *Rosellinia* is the *Trichosporium fuscum*, Sacc. (= *Sporotrichum fuscum*). At a later date, when the host is quite dead, often only after it has been dead for some years, the crowded black perithecia of the ascigerous fruit appears on the black velvety patches that had previously borne the conidial form of fruit.

Ascigerous form. Perithecia crowded, black, shining, large; asci cylindric-clavate, 8-spored, $150\text{-}170\ \mu$ long; paraphyses cylindrical, slender, longer than the asci; spores elliptical, brown.

The collar and superficial roots are the parts attacked, and the tree is usually killed within four or five years. A damp situation favours the disease.

Prillieux, *Malad. des Plantes Agric.*, 2, p. 125 (1897).

Rosellinia ligniaria (Nitschke) has been noted by Mr. W. Carruthers, F.R.S., to attack living ash-trees, eventually killing them. Specimens were exhibited at the Linnean Society's Meeting, Dec. 16, 1897.

Perithecia gregarious, conico-globose, superficial, black, sparingly covered with minute hairs, $\frac{1}{3}$ mm. diam.; asci cylindrical, 8-spored; spores blackish-brown, continuous, $16 \times 8\ \mu$.

Rosellinia echinata (Massee), a very destructive parasite,

allied to *R. radiciperda* (Massee) and *R. necatrix* (Prill.), and spreading in a similar manner by means of subterranean mycelium and conidial fruit. The following note accompanied the specimens, sent to Kew from the Botanic Gardens, Singapore, by H. Ridley, F.R.S.: 'Some months ago all the shrubs in a jungly bit of the garden, at the foot of a large *Ficus dubia*, began to die, turning black, and the long roots of the *Ficus* did the same. At first I thought some weed-killer had been carelessly thrown into the wood, but the thing increased, every plant withered and died, looking as if acid or boiling water had been thrown upon it. All kinds of Dicotyledonous shrubs and herbs, rattans, Dracaenas, and even some Diffenbachias turned black and rotted. At last the thing developed on the fig roots and on the collar and roots of all the trees and shrubs around, and appears to be a deadly fungus.'

Perithecia densely crowded, black, echinate; asci cylindrical, 8-spored; paraphyses filiform; spores fusiformly navacular, ends very acute, opaque brown, glabrous, $90\text{-}100 \times 12\ \mu$.

Massee, *Kew Bulletin*, 1901, p. 155.

Rhizoctonia violacea (Tul.) is the provisional name given by Tulasne to sterile fungus mycelium, which attacks and kills numerous different kinds of plants belonging to widely separated natural Orders. It is well known in connection with saffron, the bulbs of which are destroyed in a wholesale manner. The roots of carrot, beetroot, asparagus, lucerne, etc., are destroyed; the tubers of potatoes, and many bulbs are also attacked. The mycelium behaves in a slightly different manner, and presents a modified appearance when growing on different hosts, hence several different species of *Rhizoctonia* (all sterile) have been proposed, but infection experiments have proved the soundness of Tulasne's conclusion that all belonged to one and the same species. The infect bulb or root becomes covered with a rather loose weft of reddish-violet or brownish mycelium, which begins as a scattered, loose network creeping over the surface of the part attacked, and gradually becomes more compact and spreading, until the entire root or bulb is coated with the mycelium. The hyphae forming the superficial weft of mycelium are usually straight, 4-6 μ thick, septate, and generally give off branches at right angles to the parent hypha. When the

external weft is formed it produces two types of sclerotia. The most general type consists of numerous minute blackish-violet sclerotia which resemble in size and general appearance the perithecia of some *Sphaeria*. If a section of the host-plant bearing such micro-sclerotia is examined, the sclerotium is seen to be more or less dumbbell-shaped, a short, thick neck penetrating the tissue of the host, consisting of closely

FIG. 68.—Swede, lower half covered with mycelium of *Rhizoctonia violacea*.

packed, more or less parallel, septate hyphae, which spreads out above into a subglobose head of compactly interwoven tissue; and at the lower or basal end, again expanding into a large mass of compactly interwoven hyphae, buried in the tissue of the host. It is the mycelium of the micro-sclerotia that alone enters the living tissues and kills the host; the superficial felt of mycelium does not send mycelium into the tissues, and is so loosely attached that it can usually be rubbed off with the fingers. The second type or macro-

sclerotia are less frequent, and may attain to the size of a marble, blackish-purple in colour, and more or less velvety at the surface. These sclerotia give off long strands of dark-coloured mycelium which spread into the soil.

An ascigerous form of fruit met with on the dead roots of lucerne killed by the Rhizoctonia, and called *Leptosphaeria circinans* (Sacc.), is considered by some as representing the fruiting condition of Rhizoctonia, but this has not been definitely proved. *Hendersonia medicaginis*, Sacc. (=*Byssothecium circinans*, Fuckel), is also considered to be a pycnidial form, and *Lanosa nivalis* (Fr.), a conidial form, but there is as yet no certainty about any one of these.

The structure and colour of the mycelium and the general habit of Rhizoctonia so closely resembles that of *Rosellinia quercina*, *R. aquila*, *R. necatrix*, and other destructive parasites belonging to that genus, that I consider the Rhizoctonia as representing the vegetative condition of a *Rosellinia*.

Rolfs, on the other hand, considers that Rhizoctonia is a basidioycete, *Corticium vagum* (Berk. and Curt.), var. *solani* (Burt). Now *C. vagum* is a saprophyte on the dead bark of various conifers, hence it requires a vivid imagination to assume that a variety of this species has become a rampant parasite on the roots of a large number of different kinds of plants growing in countries where *C. vagum* is unknown. The *C. vagum*, var. *solani*, is described under *Hypochnus solani* in this book.

Leptosphaeria circinans. Perithecia erumpent, seated on reddish-violet mycelium, black; asci cylindric-clavate, 8-spored; spores elliptical, 3-septate, 2 interior cells violet-brown, terminal cells small, hyaline, $32\text{-}35 \times 10\text{-}12\ \mu$. Paraphyses slender, hyaline.

One of the most difficult of parasitic fungi to eradicate, on account of its widespread diffusion in the soil, where, even in the absence of those cultivated crops it especially prefers, it is enabled to continue its existence by attacking weeds of the most varied kind. It has been proved to maintain itself for at least twenty years in land that has produced a crop of diseased lucerne, although during this period no cultivated crop that it was known to attack had been grown. When land is infected cereals appear to be the only thing immune against its attacks. In addition, lime should be used, and the ground kept as free as possible from weeds.

An important discovery has recently been announced by

Salmon, who used phenol (carbolic acid), one ounce to one gallon of water, and forty gallons of this solution were applied to a bed 19 feet by 9 feet, with the object of testing its power of killing the sclerotia of Rhizoctonia present in the soil, before planting seakale. The seakale grew up free from disease, and the plants were apparently stimulated in growth, the crop being heavier than in any other of the test beds.

Massee, *Journ. Bot.*, 46, p. 151 (1908).
Prillieux, *Malad. des Plantes Agric.*, 2, p. 144 (1897).
Rolfs, *Colorado Agric. Bull.*, Nos. 70 and 91.
Salmon, *Gard. Chron.*, July 4, 1908.

SPHAERODERMA (Fckl.)

Perithecia globose, not beaked, seated on an arachnoid web of mycelium, ochraceous; asci 4-8-spored; spores ellipsoid, large, continuous, coloured.

Wheat-straw blight.—Saccardo and Berlèse have described a disease of wheat in Sardinia, which sometimes proves very injurious. It is caused by *Sphaeroderma damnosum* (Sacc.).

Attacked plants remain stunted, and the ear is small and does not ripen well, or in some instances the grain is not developed. Near the base of the straw the mycelium causes dark-brown patches to appear, more evident on the lower nodes. A delicate white fluffy mycelium develops between the leaf-sheath and the stem, which finally bears numerous minute, brown, dot-like perithecia. The delicate white mycelium also produces a conidial form of fruit of the *Fusarium* type, more especially during moist, hot weather.

Ascigerous form. Perithecia golden-yellow, mouth surrounded by a fringe of white hairs. Asci subglobose, containing eight olive, lemon-shaped spores, 18-20 × 10-12 μ.

Conidial form. Minute white tufts with a suggestion of pink, conidia borne in clusters on short branches springing from the tip of a branch of mycelium, fusiform, slightly curved, 3-5-septate, hyaline.

This parasite has also occurred on oats and barley.

Saccardo and Berlèse, *Rivista di Patalogia vegetale*, 1895.

Cranberry rot.—This injury is caused by *Acanthorhynchus vaccinii* (Shear). The injury to the fruit is similar to that

caused by *Guignardia vaccinii*. It first appears as a small light-coloured spot, the whole berry becoming soft. At a late stage small dark-coloured blotches appear on the inner surface of the skin of the fruit. The leaves are also attacked. The disease proves very destructive in various parts of the United States.

Perithecia scattered, the black beak, beset with continuous black spines, only bursting through the cuticle, 300-400 μ diam. Asci clavate, 8-spored, accompanied by paraphyses. Spores hyaline, then yellowish-brown, elliptic-oblong, $27\text{-}36 \times 12\text{-}20\ \mu$.

The spores are ejected from the asci in a compact mass enclosed in mucilage, as in many species of coprophilous fungi.

Treatment the same as for cranberry scald. The two diseases usually occur together.

Shear, C. L., *U.S. Dept. Agric.*, *Bureau of Plant Industry*, *Bull.* No. 110, (1907).

E. *Spores coloured*, 1-*septate*.

DIDYMOSPHAERIA (Fckl.)

Perithecia covered by the epidermis, which remains unchanged or is blackened; asci 4-8-spored, with paraphyses; spores elongated, 1-septate, coloured. Spermogonia and pycnidia frequent.

Poplar twig disease.—Prillieux states that in certain parts of France, poplars, more especially the pyramidal poplar, becomes covered with dead shoots, or frequently completely perishes. This has been attributed to various causes, as constant reproduction by cuttings, etc. The injury is in reality caused by a fungus named *Didymosphaeria populina* (Vuill.). The tips of the young shoots are killed and blackened. Infection takes place when the shoots are quite young, and is indicated by the curving and shrivelling of the tips; finally the young shoot perishes, and lateral uninjured shoots take their places. When a tree is once infected this killing of many terminal shoots occurs every spring, which weakens the tree, the effect being ultimately shown in the death of the crown. Pycnidia in immense numbers on the blackened

portions of the branches is the first form of fruit to appear; these develop during the summer after infection. In the autumn the ascigerous form of the fungus appears on the dead shoots. Finally the young leaves are infected by the spores of the ascigerous fruit; blackened patches appear, more especially towards the tip of the leaf, and near the margin. In May or June the blackened and dried-up patches become covered with a very delicate clear yellow bloom, which later changes by degrees to a deep olive colour. This conidial form of the fungus was at one time considered as an entity, and was described by Frank as a new parasitic fungus under the name of *Fusicladium tremulae* (Frank). It is also known as *Napicladium tremulae* (Sacc.).

Ascigerous form. Perithecia globose, up to $\frac{1}{5}$ mm. diam. Asci cylindrical, 8-spored; spores clear brown, of two unequal cells, largest cell nearest apex of ascus.

Pycnidia or *Phoma* form. Perithecia minute, conidia, $5\text{-}6 \times 2\text{-}2{\cdot}5\ \mu$, hyaline, elliptic-oblong.

Fusicladium form. Conidia produced on a stroma on dead patches of bark; 3-celled when mature, the central cell largest, fusiform, ends blunt, brown.

Unfortunately, owing to the difficulties of either spraying or pruning such tall trees, the disease is difficult to check. The disease is undoubtedly perpetuated from year to year by the fruit formed on young shoots that have been killed by the fungus.

Frank, *Ber. d. deutsch. Bot. Ges.*, 1, p. 29 (1883).
Prillieux, *Malad. des Plantes Agr.*, 2, 202 (1897).
Vuillemin, *Comp. Rend.*, 108, p. 632 (1889).

GIBELLINA (Pass.)

Stroma immersed, perithecia seated on the stroma or immersed, globose, with a long rather stout, curved or straight beak; asci 8-spored; spores oblong, 1-septate, coloured.

Wheat straw disease.—A parasitic fungus called *Gibellina cerealis* (Pass.) has proved very destructive to wheat in Italy, where it appears at intervals of years, and during the interval is, so far as observations go, entirely absent. About the month of May, plants that are infected become yellowish-green and drooping. When such plants are examined the

leaves, and more especially the sheathing portions, are seen to be more or less covered with rounded or elongated patches, covered with a delicate greyish-white mycelium, and bordered with brown. These patches often spread entirely over the sheath. When the fungus has reached this stage of development, the lower leaves are dead and the entire plant

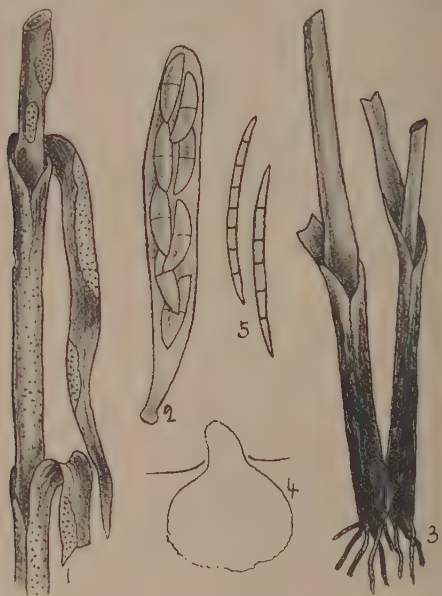

FIG. 69.—1, *Gibellina cerealis* on wheat plant, nat. size; 2, ascus with spores of same, highly mag; 3, *Ophiobolus graminis*, on wheat plant, nat. size; 4, perithecium of same, mag; 5, spores of same, highly mag.

dying, so that the ear does not escape from the sheath, or at best is but imperfectly developed. At this stage numerous perithecia are developed on the leaves, leaf-sheaths, and internodes of the stem on those portions previously occupied by the greyish mycelium, but are usually most abundant, and often confined to the inner surface of the leaf-sheaths.

Perithecia globose, sunk in the tissue of the host, neck pro-

truding, elongated, thickened upwards; asci cylindrical-clavate, 8-spored; paraphyses slightly clavate; spores elliptic-fusiform, 1-septate, rarely 2-3-septate, yellowish-brown, 22-32 × 6-9 μ.

No remedial measures suggested.

Cavara, *Zeitschr. Pflanzenkr.*, 3, p. 16 (1893).

F. *Spores coloured, more than* 1-*septate.*

PLEOSPORA (Rabenh.)

Perithecia immersed or bursting through the epidermis, membranaceous; asci clavate, 4-8-spored; spores elongated, coloured, muriform. Conidia, pycnidia and spermogonia sometimes present.

Chicory disease.—A troublesome disease which attacks chicory plants in France, more especially those that are cultivated for seed. The injury is caused by *Pleospora albicans* (Fckl.), and appears under the form of yellowish-grey spots on the lower portion of the stem. These spots gradually increase in size, and at a later stage appear on the secondary branches and on the leaves. These spots become whitish and are bordered by a dark line. At a later stage minute black dots —the perithecia—appear on these pale spots. If the weather is moist and warm, the disease spreads rapidly, and the plant is destroyed. If, on the other hand, a dry spell of weather sets in, the disease is checked, and a certain amount of seed may be produced.

A conidial *Phoma* stage of fruit is first produced, followed during the winter, on the dead plant, by ascigerous fruit.

Phoma form. Perithecia subglobose, sunk in the tissue of the host, the short mouth just protruding through the epidermis, conidia cylindric-oblong, hyaline, mixed with minute, curved spermatia. This form is *Phoma albicans* (Rob. and Desm.).

Ascigerous stage. Perithecia sunk in the matrix, depressed-globose, asci clavate, 8-spored, spores elliptic-oblong, yellowish-brown, 5-7-transversely septate, with very few vertical septa.

The ascigerous form of fruit is produced on the dead plant during winter.

Prillieux, *Bull. Soc. Myc. France*, 1896, p. 82.

Pleospora gummipara, Oud. (= *Coryneum gummiparium*, Oud.), is considered by Oudemans to cause the production of Arabian and Senegal gum, on species of *Acacia*. The cause of gumming on some species of *Acacia* has, however, been proved to be due to a bacterium, and is described on another page.

Oudemans, *Hedwigia*, 1883, pp. 131 and 161.

CUCURBITARIA (Gray)

Perithecia clustered on a stroma, globose, black; asci

FIG. 70.—*Cucurbitaria laburni*. 1, branches showing the fungus; 2, stroma in section, with perithecia; 3, ascus containing spores; 4, free spores. Fig. 1 nat. size; remainder highly mag.

cylindrical, 8-spored, spores elongated, muriform, coloured; paraphyses numerous.

Silver fir canker.—Dr. Cavara has described in detail a disease of *Abies pectinata* caused by *Cucurbitaria pithyophila* (De Not., var. *cembrae*, Rehm.). Trees are attacked up to the age of sixty years, but younger trees are most susceptible.

Rough blackish outgrowths occur on the branches which present a ringed or corrugated appearance, due to arrest of growth and shortening of the internodes. These outgrowths, under a pocket-lens, are seen to be covered with the black fruiting bodies of the fungus, embedded in a black stroma.

Perithecia densely gregarious, globose or obconic, mouth at first prominent. Asci very long, 8-spored, surrounded by paraphyses. Spores elliptic-oblong, 4-celled, ochraceous-brown, 21-23 × 7-8 μ.

Cavara, *Zeitschr. Pflanzenkr.*, 7, p. 321 (1897).

Cucurbitaria laburni (De Not.) attacks branches of laburnum, and on certain occasions, as when the branches have been cracked by frost, or injured by insects, acts as a true parasite, forming large cake-like stromata that rupture the bark.

Spores elliptic-fusoid, muriform, slightly constricted at the middle, brownish-yellow, 26-36 × 9-12 μ.

MASSARIA (De Not.)

Perithecia black, immersed, beak protruding; asci often 8-spored; spores elongated, 2-many-septate, brown, surrounded by a hyaline mucilaginous border, usually large; paraphyses slender.

Stem disease of tea plant.—Petch has described a disease of the tea plant in Ceylon, caused by *Massaria theicola* (Petch). Diseased bushes usually die gradually, branch by branch, and when dug up there is no sign of mycelium or of decay, but if the stem is split open the wood is found to be discoloured and dark, due to the presence of the blackish-violet mycelium of the fungus, which advances along the channels by which the water ascends in the stem. The diseased wood is just as solid as the rest.

Perithecia gregarious, immersed in the cortex, black; asci narrowly cylindrical, 120-160 × 20 μ, 8-spored; spores hyaline, 2-septate at maturity, olive, 17-22 × 6 μ.

Petch, *Roy. Bot. Garden, Ceylon*, 4, Circ. No. 4 (1907).

PYRENOPHORA (Sacc.)

Perithecia produced under the cuticle, then breaking through, black, setulose, often produced from a sclerotioid base; asci 8-spored; spores ovate-oblong, muriform, honey-colour or smoky.

Barley leaf stripe.—This disease was at one time attributed to *Helminthosporium gramineum* (Eriksson), which was considered as an entity. Noack, however, has recently proved that the *Helminthosporium* is a conidial condition of an ascigerous fungus called *Pyrenophora trichostoma*, Sacc. (=*Pleospora trichostoma*, Fckl.).

So far as cultivated crops are concerned the fungus attacks barley more especially, forming long brown stripes or patches with a pale border, which sometimes extend the entire length of the leaf. At a later stage numerous clusters of conidiophores grow through the stomata, or burst through the epidermis, and bear myriads of very large, sausage-shaped or spindle-shaped, dark-brown conidia. These conidia germinate at the moment of maturity, and being readily dispersed by wind, etc., an epidemic usually follows its appearance in a field. Infected plants are often stunted in growth, and do not attain to half the normal size. In many instances the ear does not protrude from the leaf-sheath at all; in others it partly escapes but becomes curved, and the tip is held back in the sheath. When the ear does fully emerge from the sheath it is usually dwarfed and remains erect instead of becoming curved or 'sickled.' Ravn has proved that the conidia of the *Helminthosporium* stage adhere to the grain, as in the case of smuts, and when the seed germinates the conidia also germinate and their germ-tubes enter the growing-point of the oat seedling. This explains why the first leaf of the seedling may show the stripe disease, and Ravn concludes that infection only takes place in the seedling stage.

Potter describes a modification of this disease in which the ears pursue the normal course of development up to the time of flowering, and examination showed that pollination had taken place. At this point, however, further growth of the flower had been arrested, and in place of the normal grain the ovary was represented by a blackened mass of dead cells, permeated with the hyphae of *Helminthosporium gramineum*. Potter considers it highly probable that in such cases infec-

tion occurred through the deposition of conidia of the fungus. When the leaves are diseased in the normal manner, I have frequently seen the ear well out of the leaf-sheath, and many or all of the grains presenting a shrivelled appearance, but this shrivelling of the grain I found to be invariably due to the work of *Thrips ceralium* (Halid).

By some authors it is considered that the fungus under observation is a biologic species, confined to barley. This idea, however, is by no means correct. During the month of June, 1908, a quantity of barley attacked by *Helminthosporium* was sent to Kew from Norfolk for investigation. With spores obtained from this material I infected a quantity of leaves of *Hordeum murinum*.

The leaves were placed on damp blotting-paper in a Petri dish, and within a week were covered with a dense mass of conidia of the *Helminthosporium*. The material was allowed to become thoroughly dry, when leaves of grasses belonging to the following genera were infected and within five days bore a plentiful crop of conidia—*Festuca ovina*, *Briza media*, *Dactylis glomerata*, *Poa annua*, and *Arrhenatherum avenaceum*. The last-named grass was attacked most vigorously, and repeated experiments proved that it was a favourite host. No infection followed with the following, *Avena fatua*, *Aira caespitosa*, and *Holcus lanatus*. When the original material was six months old—having been kept dry all the time, and at the ordinary temperature of the laboratory, a number of barley grains were dipped in very diluted gum-water, rolled on the spore-mass in the Petri dish, and then sown. Most of the grains thus treated showed the disease on the first leaf; a check lot of the same batch of seed, not infected with conidia, sown at the same time, remained free from disease. Similar results followed a second experiment conducted when the spores in the Petri dish were just one year old. These experiments prove that the conidia of *Helminthosporium*, under the conditions stated above, retain their vitality for a year, and furthermore, that when the conidia are sown along with the seed, infection of the seedling takes place, as stated by Ravn.

Sclerotia-like bodies are formed in the tissues of the leaves, and on the straw, more especially at the nodes. These bodies bear the ascigerous form of fruit the following spring.

Ascigerous form. Perithecia gregarious, conical, mouth

hispid; asci 8-spored; spores elliptic-oblong, 3-septate, constricted at the septa, middle cell often thickened and muriform, honey-colour, surrounded by a hyaline stratum, 36-48 $\times$ 18-21 μ; paraphyses branched.

Heminthosporium form. Conidiophores solitary or in small clusters, septate, coloured, often angularly bent; conidia subcylindrical, 5-9-septate, brownish, 50-125 $\times$ 14-21 μ.

As the seedlings are infected by spores adhering to the seed, treating the seed with a solution of formalin, as recommended for loose smut of oats, should be of service. As it is proved that the fungus is capable of developing on many of our common grasses, it behoves the farmer to keep headlands, hedges, and ditches free from such grasses. This is, I am quite aware, carried into effect by most good farmers, notwithstanding the dictum of an academic professor that such a method is impracticable, and only a mycological myth.

Noack, *Zeitschr. Pflanzenkr.*, 15, p. 193 (1905).

Potter, *Observations on a disease producing the 'deaf-ear' of the barley.*

Ravn, *Zeitschr. Pflanzenkr.*, 11, p. 13 (1901).

HYSTERIACEAE

The characteristic feature of the present group is the elongated perithecium, which opens by a long slit throughout its entire length. The perithecium may be linear, stellate, with several radiating arms, or shaped like a mussel shell standing on end. The slit or opening of the perithecium is usually bounded by thickened margins. At one time included in the Discomycetes, the coriaceous or carbonaceous perithecia, and usually coloured, septate spores, indicate closer relationship with the Pyrenomycetes.

Minute fungi, generally black, and as a rule saprophytic on wood, twigs, leaves, etc. A few are parasitic on leaves and stems.

Massee, Geo., *British Fungus-Flora*, 4.

LOPHODERMIUM (Chev.)

Ascophore immersed, elliptical, black, opening by a narrow slit; spores needle-shaped, hyaline, continuous, arranged in a parallel fascicle in the ascus.

Usually saprophytes on dead leaves or stems.
Ascophores often gregarious on bleached spots.

Pine leaf cast (*Lophodermium pinastri*, Chev. = *Hysterium pinastri*, Schrad.) is the cause of a serious disease to seedling conifers, which results in the leaves being shed; if this occurs for two or three years in succession the trees are killed outright. According to Hartig the disease may frequently be observed even in the first autumn, by the

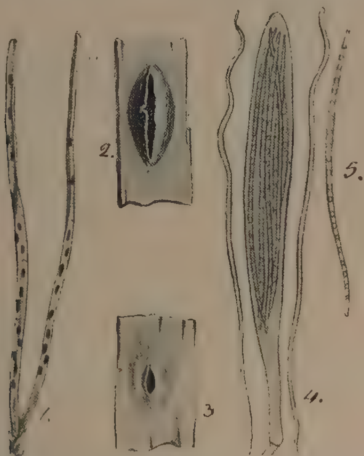

FIG. 71.—*Lophodermium pinastri*. 1, fungus on pine leaves; 2, ascigerous form of fungus; 3, conidial form; 4, ascus with spores; 5, a single spore. Figs. 2-5 mag.

primary leaves showing brown blotches, while other portions become purple-red. Even at this early stage the characteristic mycelium may be found in the brown blotches. During the first year after infection a large number of minute black spots, representing a conidial form of the fungus, are produced, the contents of which do not appear to be capable of germination. As a rule, the ascigerous form of the fungus does not appear till the following season, but this depends much on the weather. Dry summers and cold winters check the development of the fungus, whereas its growth is favoured

by wet summers and mild, damp winters. Attacked seedlings usually die, and can only recover when about half the number of leaves remain healthy.

The ascophores are scattered on pale spots on the leaf, shining black, up to 1 mm. long; asci clavate, 8-spored, spores nearly as long as the ascus, $90\text{-}120 \times 1{\cdot}5\ \mu$.

Conidia cylindrical, colourless, continuous, $6\text{-}8 \times 1\ \mu$. Called *Leptostroma pinastri* (Desm.)

On leaves of Scotch fir and other conifers. The leaves of old trees are also attacked.

To secure seedlings free from disease the seed-beds should be formed at a distance from infected areas, otherwise the spores may be carried by wind or other agents. Where tracts have been devastated by the disease, the trees should be replaced by Weymouth pines, which are immune.

Hartig and Somerville, *Text-Book of Diseases of Trees*, (Engl. ed.), p. 110 (1894).

DICHAENA (Fries.)

Ascophores crowded and forming extended black patches, rounded or elongated, opening by an elongated slit; asci obpiriform or broadly fusiform, 4-8 spored; spores septate, hyaline; paraphyses slender.

True parasites on living bark, but do little or no injury. Often sterile.

Oak bark blotch.—The flat, rough black patches varying in size from 1 to 3 cm., so common on the bark of living oak branches, are caused by *Dichaena quercina* (Fries.)

Two forms of pycnidia are first produced which resemble the ascophores in form. One contains myriads of hyaline, elliptical spores about $5 \times 3\ \mu$. The other produces larger, broadly elliptical hyaline spores, borne singly on slender pedicels, $22\text{-}25 \times 8\text{-}10\ \mu$. Asci broadly piriform, sessile, 8-spored; spores elliptical, hyaline, 1- then 3-septate (said to become muriform), $21\text{-}25 \times 8\ \mu$.

Dichaena faginea (Fries.), which resembles *D. quercina* in appearance, grows on smooth living beech bark.

Other species or varieties of similar appearance occur on bark of hazel and goat willow.

DISCOMYCETES

The typical form of the ascophore in the higher forms is that of a shallow cup, either sessile or supported on a stem. When young the margin of the ascophore is strongly incurved, but gradually expands and exposes the hymenium, which is often brightly coloured. In some of the minute kinds, that grow immersed in wood, or in the tissues of leaves, the cup-like form is not apparent, and the disc or hymenium may be plane or convex, without any margin. The substance of the ascophore is soft and often fleshy, never carbonaceous as in the Pyrenomycetes.

The majority are pure saprophytes, although some of the minute species are destructive parasites. Some of the larger kinds, as the Morels (*Morchella*) are edible. None are known to be poisonous. Conidial stages are produced in some instances. The species of *Sclerotinia*, which are all parasites, form sclerotia.

Massee, Geo., *British Fungus-Flora*, 4.

A. *Spores hyaline.*

CYTTARIA (Berk.)

Ascophore obovate or subglobose, fleshy, stuffed or hollow, surface with sunken pits lined with the hymenium, and at first covered by a veil; asci cylindrical, 8-spored; spores elliptical, continuous, hyaline; paraphyses numerous.

Tree morel (*Cyttaria gunnii*, Berk.) is parasitic on *Fagus Cunninghamii*, the Tasmanian myrtle-tree. It grows in dense clusters on the branches; the mycelium is perennial and forms rough knobs or swellings which produce the fungus every season. It was used as food by the aborigines.

Broadly pear-shaped, becoming hollow, loculi on surface, small, dehiscing by an irregular large opening, whitish; asci cylindrical, 8-spored, spores elliptical, hyaline.

Cyttaria berteri (Berk.) grows on *Fagus obliqua*, in Tierra del Fuego, Patagonia, and Chili.

Cyttaria darwinii (Berk.) grows on *Fagus antarctica* and *F. betuloides*, in Chili.

Cyttaria hookeri (Berk.) grows on *Fagus obliqua* and *F.*

antarctica, in Tierra del Fuego, Patagonia, and Hermite Island, Cape Horn.

FIG. 72.—*Cyttaria gunnii*. 1, fungus on living branch of *Fagus Cunninghamii*, somewhat reduced; 2, section of a fungus; 3, ascus and spores, highly mag.

All the species are edible, and closely resemble each other. All are parasitic on the southern evergreen species of *Fagus*.

PEZIZA (DILL.)

Ascophore sessile, fleshy and brittle, externally warted or scurfy, globose and closed when young, gradually expanding until cup-shaped or almost plane; asci containing 8 spores in a single row; spores hyaline, elongated, continuous.

Growing on the ground or on manure, etc. Among the

largest of the cup-shaped Pezizae, known by the thick, brittle, watery substance, never hairy nor spiny outside. Ludwig has stated that *Peziza vesiculosa* (Bull.) sometimes becomes a true parasite; he found it attacking species of *Balsamina*, *Hyacinthus*, *Sidalcea*, etc. Plants supposed to have been killed by the fungus, when placed under a bell-jar were soon covered with the conidial form of the fungus, first described by Brefeld, who produced this form from germinating ascospores. The ascospores are clustered and often irregular from

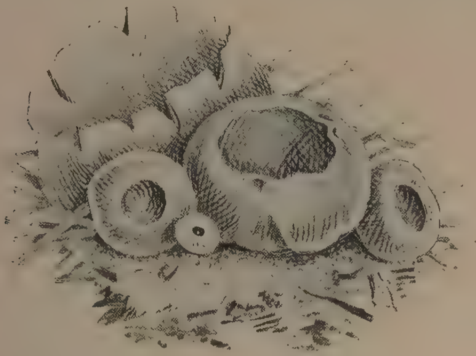

FIG. 73.—*Peziza vesiculosa.* Group of fungi, nat. size.

mutual pressure, externally brownish and coarsely granular, disc pale brown, 3-7 cm. across; asci long, cylindrical; spores elliptical, hyaline, smooth, $21\text{-}24 \times 11\text{-}12\ \mu$.

The conidial form belongs to the form-genus *Cephalosporium*, pure white, sterile hyphae creeping, giving off numerous short lateral branches of about equal length, each tipped by a swollen head covered with elliptical, hyaline, continuous spores, $8\text{-}10 \times 3\text{-}4\ \mu$. Common on rich soil, manure heaps, rotten leaves, etc.

Brefeld, O., *Unters. Gessammt. Mykol.*, 9 Heft, p. 333, pl. 13, figs. 16-28 (1891).

Ludwig, *Zeitschr. für Pflanzenkr.*, 1895, p. 12.

RHIZINA (Fries.)

Ascophore entirely sessile, expanded from the first, fleshy, under surface furnished with numerous tufts of hyphae; asci cylindrical, 8-spored, spores elongated, continuous, hyaline.

Readily recognised by the dark-brown, crust-like ascophore, furnished on the under surface with numerous rhizoids or tufts of hyphae, by which it is fixed to the substratum.

Rhizina inflata (Quel.) is a fairly common British fungus, met with on burnt soil, peat, etc., and often occurs abundantly on old heaps of sawdust. The ascophore is somewhat convex, more or less circular, margin often lobed, smooth, dark brown,

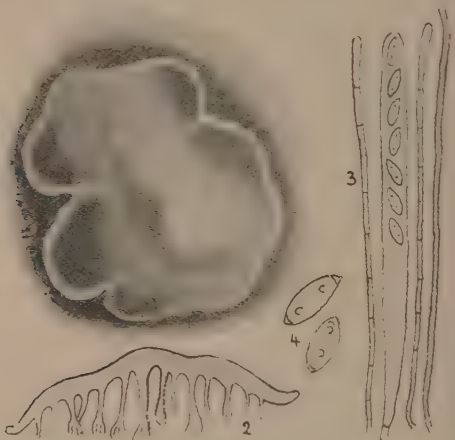

FIG. 74.—1, *Rhizina inflata*, nat. size; 2, sections of fungus showing rhizoids, nat. size; 3, ascus containing eight spores, also three paraphyses, highly mag.; 4, two free spores showing the thickened ends, highly mag.

3-10 cm. across; asci cylindrical, spores fusiform, $32\text{-}36 \times 9\text{-}10\ \mu$; paraphyses numerous, tips brown.

Professor Hartig has shown that this fungus is parasitic on the roots of young trees, more especially conifers, as *Abies pectinata*, *Tsuga mertensiana*, *Pseudotsuga douglasii*, *Picea sikkaensis*, *Pinus strobus*, and *Larix europaea*. It also attacks the roots of *Castanea vesca*. On removing a plant that has

been killed by the fungus, a dense weft of mycelium is found at the root, which firmly binds together a mass of sand or earth. This is due to outflow of resin. On careful examination numerous filaments of hyphae are seen to spring from the bark. The tissues of the soft bark and the cortex turn brown and are killed. Hartig observed the production of immense numbers of very minute sporules, about 1-1·5 μ, borne on very short stalks springing from the tips and sides of hyphae that grew from the infected roots.

The fungus should be collected and buried. As already stated, it is often produced in abundance on old heaps of sawdust, or on the sites of charcoal pits or fires. Most abundant on a sandy soil.

Hartig and Somerville, *Text-Book of the Diseases of Trees* (Engl. ed.), p. 123 (1894).

RHYTISMA (Fries.)

Ascophores elongated, lips gaping and exposing the pale disc when mature; asci clavate; spores long and slender, hyaline, continuous, arranged in a parallel fascicle in the ascus; paraphyses very slender; conidia usually produced.

Forming large black patches on living leaves, conidia are formed during the autumn, and ascospores the following spring on the dead leaves.

Sycamore leaf blotch (*Rhytisma acerinum*, Fries.) produces the large black spots resembling blotches of pitch so common on the living leaves of sycamore and maple, and familiar to every one, although not always associated with the work of a parasitic fungus. About the end of June small pale-green or yellowish spots appear on infected leaves. These spots gradually increase in size and change by degrees to a continuous patch of jet-black, surrounded by a dingy yellow border. When fully formed the black patch is thicker than the substance of the leaf proper, due to the formation of a thin stroma by the fungus, the surface of which is wrinkled or corrugated. During the autumn immense numbers of very minute spore-like bodies, or spermatia, are borne in conceptacles in the black stroma, whose use is unknown; they have not been observed to germinate, and are not capable of promoting infection. They probably represent what were at

one time male or fertilising bodies. After the dead infected leaves have been lying on the ground throughout the winter, ascospores are formed in cavities in the stroma. These ascospores escape into the air in the spring and infect the young leaves.

The spermatia are cylindrical, hyaline, about $6\text{-}9 \times 1\ \mu$. Ascospores needle-shaped, hyaline, often slightly curved, $60\text{-}80 \times 1{\cdot}5\text{-}2{\cdot}5\ \mu$; paraphyses very slender, tips curved.

The disease sometimes proves to be very destructive directly

FIG. 75.—*Rhytisma acerinum*. 1, sycamore leaf with blotches caused by fungus; 2, section through a blotch bearing conidia; 3, ascus with spores, also two paraphyses; 4, an ascospore. Figs. 2-4 mag.

and indirectly. Several large patches are frequently present on a leaf, and as a rule, when the disease is present, nearly every leaf is attacked, hence a considerable area of leaf surface is prevented from doing its work. In addition diseased leaves fall early, and as the disease, unless checked, appears year after year, the tree becomes enfeebled owing to lack of food, and badly matured wood, when it easily falls a prey to a yet more dangerous parasite, the coral spot fungus (*Nectria cinnabarina*), which often follows an epidemic of leaf blotch.

When the diseased leaves have fallen, the tree is perfectly clear of the fungus, and the only possible means of further infection is due to spores alighting on the young leaves, and

such spores escape into the air from the dead, diseased leaves that have been lying on the ground throughout the winter. If such diseased leaves are swept up and burned before the young leaves unfold, infection is prevented.

Rhytisma punctatum (Fries.) is a somewhat less common parasite than *R. acerinum*. It also forms large black blotches on living leaves of sycamore and maple, and is distinguished by the blotch being formed of a large number of small, distinct patches being crowded together on a yellowish ground. The two parasites are often to be met with on the same leaf.

Spermatia cylindrical, hyaline, $5\text{-}6 \times 1{\cdot}5\ \mu$. Ascospores needle-shaped, $35\text{-}40 \times 1{\cdot}5\text{-}2\ \mu$.

Treatment same as for previous fungus.

Rhytisma onobrychidis, D. C. (= *Placosphaeria onobrychidis*, Sacc.), forms irregularly shaped black patches on living leaves of sainfoin (*Onobrychis sativa*, L.). Scattered spots first appear on the under surface of the leaf; these increase in size and become confluent, forming wavy, warted, and cracked patches of a shining black. Corresponding patches on the upper surface are of a dead black. Spermogonia only are known; these contain minute oblong-obovate spermatia, which on becoming free carry their filiform pedicel along with them.

As a rule, this parasite does but little harm; now and again, however, it does a considerable amount of injury.

Prillieux, *Bull. des séances de la Soc. Nat. d'Agric.*, 1883, p. 312.

Rhytisma salicinum (Fries.) forms circular or irregular, thickish, shining black patches on the upper surface of living leaves of various kinds of willow.

Spermatia $5\text{-}6\ \mu$ long. Ascospores needle-shaped, $65\text{-}95 \times 1{\cdot}5\text{-}2{\cdot}5\ \mu$.

Rhytisma andromedae (Fries.) forms shining black patches, or frequently covers the entire upper surface of living leaves of *Andromeda polifolia*.

Ascospores elongated and narrowly clavate, $50\text{-}60 \times 5\text{-}6\ \mu$.

EPHELINA (Sacc.)

Ascophores gregarious on an effused stroma, at first tuberculose, then splitting open; asci cylindrical, 8-spored, spores elongated, continuous, hyaline.

Parasitic on living roots.

Yellow-rattle root knot.—Black gouty swellings are formed at the base of the stem or the root of *Rhinanthus crista-galli*, by *Ephelina radicalis* (Mass.); spores slightly but distinctly club-shaped, 10×4-$5\ \mu$.

Dr. Cooke states that he observed stylospores on the stroma early in the season, fusiform, acute, 3-septate, $70 \times 5\ \mu$. This description suggests a *Fusarium*, which may possibly have been accidentally present. The point requires investigation.

PHACIDIUM (Fries.)

Ascophores scattered, formed in the substance of the leaf, on which they develop, disc exposed by the splitting of the epidermis of the leaf into several sharp teeth, spores 8 in an ascus, arranged in two irregular rows, hyaline, elongated, continuous.

Growing on leaves, mostly saprophytes, recognised by the epidermis of the leaf splitting into several acute teeth, and exposing the disc.

Pine leaf fungus (*Phacidium infestans*, Karst.) appears under the form of small, scattered, circular blackish spots on living leaves of the Scots fir (*Pinus silvestris*). When mature, the epidermis of the leaf splits from the centre into several irregular teeth, exposing the pale disc. Asci clavate, spores fusiform, 22-23×7-$10\ \mu$; paraphyses numerous, very slender.

This fungus is apparently rare in this country, but is said to be very injurious to the Scots fir in Finland.

TYMPANIS (Tode.)

Ascophores gregarious, bursting through to the surface from an immersed stroma, closed at first, then expanding, dingy, often covered with white scurf; asci clavate, containing numerous minute, hyaline, continuous spores.

Growing on branches, probably many of our species are parasites. In some species eight large spores are present in an ascus in addition to numerous minute ones, which suggests that the minute spores are produced by budding from the larger ones, as in *Taphrina*, *Exoascus*, and some species of *Nectria*.

Bark fungus (*Tympanis conspersa*, Fries.) often occurs on living bark of birch and poplar. Ascophores top-shaped, 20-40, springing from a stroma, closed at first, then exposing the black disc, margin sprinkled with a little white meal at first, wall of ascus thick, spores numerous, $1\text{-}2 \times 0{\cdot}5\ \mu$.

Spermogonia in minute conceptacles of the stroma, usually

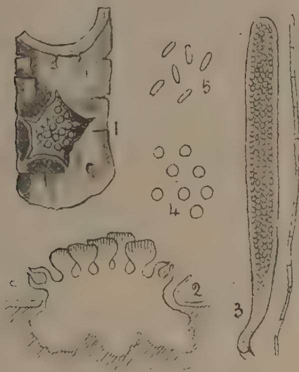

FIG. 76.—*Tympanis conspersa*. 1, group of fungi on wood. 2, section of same; 3, ascus containing numerous spores; 4, spores; 5, conidia. Figs. 2-5 mag.

mixed with the ascophores, spermatia cylindrical, $2{\cdot}5 \times 0{\cdot}5\text{-}1\ \mu$.

A variety called *mali* (Rehm.), having fewer ascophores, 4-10 in a cluster, occurs on bark of apple, hawthorn, mountain-ash, and other rosaceous plants.

CRYPTOMYCES (GREV.)

Ascophores immersed in a white stroma covered by the blackened epidermis which is firmly united to the black crust of the stroma, finally opening by long cracks; asci cylindrical, 8-spored; spores continuous, hyaline, elliptical.

Forming large black patches on branches, superficially resembling *Rhytisma*, differing in the spores and white stroma.

Willow branch blotch.—Large, black, blister-like patches varying from 1-10 cm. long are formed on the branches of different kinds of willow, by *Cryptomyces aureus* (Mass.) The margin of the patch is well defined and often lobed, and at maturity the black upper surface breaks away from the surrounding bark and often falls off.

Spores arranged in one row in the ascus, elliptical, colourless, then yellowish, $20\text{-}25 \times 10\text{-}12\ \mu$. Spermogonia are produced in special receptacles in the stroma, containing minute ovate spermatia about $5\ \mu$ long.

SCLEROTINIA (Fckl.)

Ascophore smooth, brown, supported on a long, slender stem, springing from a blackish sclerotium, asci narrowly cylindrical, containing 8 spores in a single row, spores elongated, hyaline, 1-celled.

In several species a conidial form is known, which may belong to either of the following form-genera, *Botrytis*, *Monilia*, and *Oidium*.

Closely allied to *Ciboria*, which differs in the ascigerous stage not originating from a sclerotium.

Many of the species are very destructive parasites.

Vine Sclerotinia (*Sclerotinia fuckeliana*, De Bary) is often the cause of very serious injury to the vine ; every part of the plant is attacked, the leaves and fruit more especially becoming covered with a dense, fluffy, mouse-coloured mould, covered with myriads of spores, which become free and float about and infect other portions of the vine. At a later stage small black sclerotia are produced in the substance of the plant at those points that were covered with mould. During the following spring these sclerotia produce either the conidial or ascigerous form of fruit, depending on certain conditions as to temperature, moisture, etc. Istvanffi states that a continuous rainy period favours the development of the *Botrytis* condition, especially on sclerotia that have fallen to the ground, or are attached to fallen leaves or fruit. Sclerotia that remain attached to living branches often produce the ascophore form of fruit in the spring, and the spores escaping from such fruits are capable of infecting the

vine directly. Istvanffi has written a very detailed account, profusely illustrated, of the vine sclerotinia.

FIG. 77.—*Sclerotinia fuckeliana.* 1, vine leaf with *Botrytis* form of fungus; 2, conidiophores of *Botrytis*; 3, a head or cluster of conidia; 4, sclerotia bearing *Botrytis* form of fruit; 5, a sclerotium bearing two ascophores; 6, like fig. 5, on a larger scale; 7, a shrivelled grape with sclerotia; 8, ascus with spores. All except Fig. 1 mag.

Ascophores yellowish-brown, 0·5-4 mm. across, stem slender, 2-3 springing from a small black sclerotium; spores 10-11 × 6-7 μ.

Conidial form. Sterile hyphae prostrate, fertile ones erect, forming dense grey tufts, simple or slightly branched, ends spinulose, bearing heads of conidia; conidia subglobose with usually a minute apiculus, almost hyaline, 10-12 μ. Vines grown under glass alone suffer from the disease in this country, and as the fungus can only thrive in a very damp atmosphere, early morning ventilation is of the utmost importance. Spraying with sulphide of potassium arrests the disease; and when the fungus has once occurred, a thorough spraying of the plants *when resting*, and of the entire house, with a solution of sulphate of iron is advisable.

Infected leaves and fruit should at once be removed.

De Bary, A., *Morphol. and Physiol. of Fungi* (Engl. ed.), p. 224.

Istvanffi, *Ann. Inst. Ampél. Hongr.*, 2 (1902).

Snowdrop mildew.—A fungus named *Sclerotinia galanthina* (Ludwig), but which may prove to be nothing more than *S. fuckeliana* (De Bary), often attacks snowdrops as they appear above-ground. The leaves and flowers, instead of developing properly, are much contorted and completely covered with a dense felt of grey mould. Numerous minute black sclerotia are formed on the diseased leaves and flowers, and also on the outer bulb-scales. The mould is of the usual *Botrytis* type, but the spores differ slightly in size and form from those of other known species, whether this variation is due to the host upon which it grows, or is of specific importance, remains to be proved. The ascophore condition is unknown.

The conidial condition was first described as *Botrytis galanthina* (Berk. and Broome). Hyphae shortly branched upwards, branchlets thickened at the tips, coloured; conidia obovate, $15\text{-}18 \times 10\text{-}11$ μ, forming heads, springing from slender sterigmata.

Plants that are once attacked never bloom, but produce the disease year by year. The bulbs of all diseased plants should be removed and destroyed. Remove the upper two inches of soil from places where the disease has existed, and replace by fresh soil mixed with a small quantity of powdered sulphur.

Ludwig, *Lehrb. der nieder. Kryptogamen*, p. 335.

Douglas fir blight.—A grey mould that often kills large numbers of seedling conifers of different kinds, was at one

time attributed to a fungus called *Sclerotinia douglasii* (Massee), or *Botrytis douglasii* (Tubeuf). It has, however, now been shown that this fungus is identical with *Sclerotinia fuckeliana* (De Bary), the cause of the vine disease. Attacked seedlings are often killed outright during the first season; the leaves turn yellow and fall, and the branches become more or less covered with tufts of grey, fluffy mould. At a later stage numerous minute black sclerotia are formed in the bark. The lead and upper shoots of older trees are also sometimes attacked. In addition to the Douglas fir (*Pseudotsuga douglasii*), the Wellingtonia (*Sequoia gigantea*) and the juniper (*Juniperus communis*) suffer from this disease. Other kinds of conifers are also probably attacked.

In the case of nursery stock spraying with Bordeaux mixture will check the extension of the disease. Seedlings that have the lead injured should be removed and burned, otherwise the sclerotia present in the bark will form fruit the following season, and a fresh outbreak will occur.

Massee, G., *Journ. Board Agr.*, 1905.
Tubeuf, *Beitr. Keuntniss Baumkr.*, 1888.

Lettuce stem canker.—Lettuce that is grown under glass frequently suffers severely from a disease indirectly caused by *Sclerotinia fuckeliana* (De Bary). The injury usually commences on the stem near the ground, afterwards the leaves are attacked, finally the entire plant wilts and dies. The stem on examination presents a cankered appearance, and is sometimes almost eaten through, so that the plant breaks off at the root. The lower part of the stem and leaves are covered with a dense greyish mould, called *Botrytis cinerea* (Pers.), which is now known to be only a conidial condition of the *Sclerotinia*. Now this *Botrytis* condition is abundant everywhere on decaying and dead plants where it lives as a saprophyte, but when conditions are favourable it often becomes a parasite on living plants. The necessary conditions are brought about when plants are grown in a very damp atmosphere, with the soil constantly wet, and a lack of proper ventilation. Under this kind of treatment the cell-walls of plants are very thin, and the cells constantly distended with watery cell-sap, conditions under which *Botrytis* is alone able to enter the living tissues of a plant. When once inside the plant rotting commences at once. From the

above account it will be seen that excess of moisture in the soil and in the air is the primary cause of the disease, the fungus being only a secondary agent, although responsible for the greatest amount of injury; but for an imperfect mode of cultivation it could not have proved injurious. It will probably be argued that a considerable amount of moisture constantly present in the soil is a necessity under the conditions; this may be so, nevertheless it is the primary cause of the trouble. Lettuce grown out of doors is not subject to this disease.

Good ventilation, also good drainage to prevent a sodden condition of the soil, are of primary importance. Spraying with potassium sulphide, which can only be done while the plants are young, will check the rapid spread of the disease; in fact, even if no disease is present, spraying, so as to wet the surface of the soil, will do much to prevent infection. Where disease has existed it may be taken for granted that the soil is infected, and should be sterilised before another crop is sown.

Bulb sclerotinia (*Sclerotinia bulborum*, Rehm.) often proves very destructive to bulbs, including those of the onion, hyacinth, *Scilla*, *Crocus*, etc. The first indication of the disease is the presence of yellow stripes and blotches on the leaves during late spring or early summer. If the weather is damp and cloudy these yellow spots soon produce a crop of minutely velvety, olive-brown mould; this is the conidial or *Botrytis* form of the fungus, the spores of which are produced in quick succession during the summer, and are washed by rain or carried by wind to adjoining plants, which are in turn infected. The mycelium passes down the leaves and stem into the bulb, where it forms small black sclerotia in the substance of the bulb-scales, more especially the outer ones. During the following spring ascophores on slender stems sometimes spring from the sclerotia. At other times the sclerotia bear the *Botrytis* form of fruit.

Ascophore brown, 8-12 mm. across, stem elongated, slender; spores $14\text{-}16 \times 7\text{-}8\ \mu$. Spores of *Botrytis* form elliptical, hyaline, $9\text{-}10 \times 7\ \mu$.

When the yellow patches are first seen on the leaves, spray with potassium sulphide; it is important to spray uninfected plants also; this checks the spread of the epidemic, but does not prevent the mycelium from passing into the bulbs of plants already infected. Badly infected bulbs, having

numerous sclerotia showing as little black warts embedded in the bulb-scales, should be destroyed. Where a diseased crop has grown the land will be infected, and should not be planted with susceptible plants for at least three years. Removing the upper two inches of soil overlying bulbs remaining in the ground should be done during the winter, and replaced by fresh soil containing a sprinkling of sulphur.

Massee, G., *Gard. Chron.*, 16, p. 160, fig. of *Botrytis* and ascophore stages.

Wakker, *Allgem. Verun. voor Bloembollencultur*, 1883-84.

Tulip mould.—A species that has been called *Sclerotinia parasitica* (Massee), often proves very injurious to tulips. Olive-brown, velvety patches are formed on the leaves, stem, and flowers. At a later stage small blackish sclerotia are formed at the base of the stem and on the outer bulb-scales, these are often very numerous and closely packed.

The late Professor Marshall Ward described a *Botrytis* that formed orange-brown or buff blotches on leaves, stem, and flowers of *Lilium candidum*. Whether this is the same species as the one noted above is not certain. No ascigerous form was observed; however, independent of this, Ward's paper is a masterpiece of accurate research, and should be studied by all those interested in the subject of plant pathology.

Conidiophores grey, erect, basal joint swollen; conidia obovate, on short umbellately arranged branches, almost colourless, $16\text{-}21 \times 10\text{-}13\ \mu$.

Ascophore unknown.

Marshall Ward, 'A Lily Disease,' *Annals of Botany*, 2, p. 319, pl. 20-24 (1889).

Anemone sclerotinia (*Sclerotinia tuberosa*, Fckl.) often does considerable damage to the wood anemone (*Anemone nemorosa*), and to cultivated kinds of anemone. I have frequently met with large batches of anemone in woods completely overrun by this fungus, and at one time it was very abundant and destructive in Kew Gardens. No *Botrytis* condition is known to exist. The dark-brown ascophores are supported on a long slender stem, the greater portion of which is buried in the ground. The cups are at first top-shaped and closed, then funnel-shaped, and finally almost flat and but little raised above the ground, and on account of

their brown colour are apt to be overlooked, even when abundant.

Ascophore 1-3 cm. across, stem 2-7 cm. long; spores 8 in an ascus, elliptical, $15\text{-}18 \times 6\text{-}7\ \mu$.

Collecting the ascophores tends to check the disease.

Sclerotium disease (*Sclerotinia sclerotiorum*, Massee) is probably parasitic on a greater number of different kinds of plants than any other fungus, members of all the families of cultivated plants being attacked. White and swede turnips, cabbages, carrots, broad and haricot beans, potatoes, cucum-

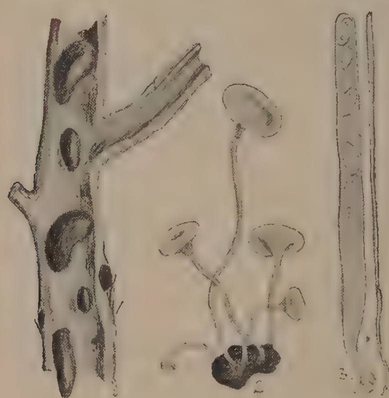

FIG. 78.—*Sclerotinia sclerotiorum.* 1, part of a chrysanthemum stem with black sclerotia of the fungus; 2, a sclerotium bearing five ascigerous fruits; 3, ascus with spores. Figs. 2 and 3 mag.

bers, melons, hemp, petunias, zinnias, and chrysanthemums being among the number of its victims. The disease commonly attacks the stem, commencing as a white mould at the ground-line and working upwards. When the parasite has been at work for some time the leaves turn yellow and wilt, and finally the stem collapses, death being due to lack of food and water, owing to the mycelium of the fungus having choked up the vessels, and thus retarded the passage of water up the stem. When the stem is hollow the mycelium is produced in considerable quantity in the cavity, and forms large

numbers of sclerotia, varying in size from a turnip seed to that of a pea, white, then black externally. When the stem is solid the sclerotia are formed in its substance, and visible on the surface. If diseased stems are allowed to lie and decay on the ground, or even if they are placed on a heap in some out-of-the-way corner, the sclerotia remain on the ground when the stems decay, and the following spring give origin to several brown, funnel-shaped ascophores borne on long, slender stems. The spores from these fungi infect plants on the spot, or are blown about by wind, and start the disease in a new locality.

In the case of plants producing tubers or fleshy roots, as mangolds, turnips, potatoes, etc., the mycelium also passes downwards into these parts, and eventually forms sclerotia, more especially if sweating occurs after storing. If such infected tubers, etc., are planted disease follows.

It is not definitely known as to whether a *Botrytis* condition s present. De Bary, who first accurately studied the fungus, considers that there is no *Botrytis* stage. Other investigators, however, state that this phase does occur. When the spores of the ascophore fruit first germinate, the mycelium cannot directly attack living plants as a parasite, but requires to live for some time as a saprophyte, obtaining its food from humus, and afterwards passes on to the parasitic condition.

The sclerotium is usually elongated, and sometimes is 2 cm. long, although generally shorter. From 1-4 ascophores spring from a sclerotium, at first closed, then funnel-shaped, finally almost flat, pale brown, 3-7 mm. across. Spores 8 in an ascus, elliptical, $9\text{-}13 \times 4\text{-}6\ \mu$.

Diseased stems should be burned, and not allowed to lie about, for the reasons given above. In flower-beds, etc., where this disease has previously existed, two inches of the surface soil should be removed, and replaced by fresh soil mixed with a little quicklime. Green stable manure favours the disease.

De Bary, A., *Bot. Ztg.*, 1886, p. 458.

Drooping disease of paeonies.—A very injurious parasite that has been called *Sclerotinia paeoniae* (Massee), but which may not eventually prove to be a distinct species, often causes the stems of paeonies to droop and die within the course of

a few days, just about the time when the flower-buds are well developed. If such a drooping stem is examined, the point where it emerges from the ground will be seen to be covered with a white mould, which extends for some distance up the stem.

If the stem is allowed to fall and remain on the ground, numerous small black sclerotia are formed in its substance, and the following season these sclerotia produce a crop of the white mould or *Botrytis*, the spores of which infect the young paeony stems. The fungus also forms sclerotia on the dead portion of the stem underground, and on fragments of plants or humus in the soil.

Conidiophores pale brown, erect, numerous, not tufted, but forming a thin continuous mould, branched, tips dilated; conidia forming white heads, ovate-oblong.

Ascophores unknown.

Stems that commence to droop should be removed at once, as they invariably die before the flowers expand; as much of the stem below ground as possible should be cut out. Where the disease has existed, the surface soil should be removed, and replaced by fresh soil, mixed with a sprinkling of flowers-of-sulphur. Mulching with green stable manure favours the disease.

Clover sickness.—This expression is used in the country when clover fails to produce a satisfactory crop. The phrase 'clover sick' is also applied to land in some districts to express the same condition of things. Clover sickness may arise from two distinct causes, that is, the primary cause may be due to 'eelworms,' or it may be a parasitic fungus called *Sclerotinia trifoliorum* (Eriksson). The latter cause is dealt with here. The first indication of disease is a wilting and yellowing of the leaves, which, if carefully examined, will be found to be more or less covered with very delicate white mycelium, which during damp weather spreads from one plant to another. During the summer numerous small black sclerotia are produced on the dead leaves, stems, and roots. Ascophores are eventually produced on the sclerotia, and the spores from the ascophores infect the leaves directly.

The disease usually originates in one or more small patches in a field, which are first indicated by a sickly greenish-yellow colour. If the weather is damp these patches quickly increase in size, and may soon become almost or quite bare owing to

the death of the clover. The presence of small black sclerotia partially embedded in the substance of the stem and root indicates that the injury is due to the *Sclerotinia*.

As a rule, only one ascophore springs from a sclerotium, at first closed then expanding, yellowish-brown 3 mm. to 1 cm. across, stem elongated, slender; spores 8 in an ascus, hyaline, elliptical, 16-18 $\times$ 8-9 μ. Conidial condition unknown.

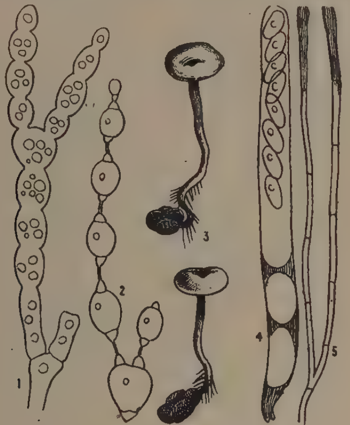

FIG. 79.—*Sclerotinia urnula*. 1, chain of conidia in young stage; 2, chain of conidia at maturity; the narrow necks or disjunctors deliquesce, and set the conidia at liberty; 3, ascophores springing from mummified fruits; 4, ascus with spores; 5, paraphyses. All figs except 3 mag.

This is a very difficult disease to combat; if diseased patches are observed while yet quite small in area, the clover should be cut, and after remaining for some time to dry, some dry litter should be spread over the diseased patch, and set on fire. By this means all the sclerotia are destroyed. Clover should not be sown on infected land for some years after an epidemic. A dressing of kainit is good for infected land.

Cowberry sclerotinia, *Sclerotinia urnula*, Rehm. (= *S. vaccinii*, Woron.), produces its conidial form of fruit, under the form of a snow-white, thin mildew on the living stems and leaves of the cowberry (*Vaccinium vitis-idaea*). This mildew belongs to the form-genus *Oidium*, and was at one

time considered as an independent plant. The mature conidia have a strong smell, resembling almonds, that proves attractive to flies, who unconsciously convey the spores on to the stigma of the *Vaccinium* flowers. Such conidia germinate on the stigma, and send their germ-tubes down into the ovary, where they form a sclerotium. Such infected fruits soon become hard and dry and fall to the ground where they remain until the following spring, when they give origin to one or more ascophores.

Ascophores often solitary, rarely two from a sclerotium, chestnut colour, 5-15 mm. across, stem often crooked, slender, fixed to the ground by rhizoids at the base; spores 8 in an ascus, elliptic-oblong, of two sizes, the largest $12\text{-}15 \times 5\text{-}6\ \mu$, the remaining four slightly smaller. Conidia in chains, lemon-shaped, colourless, $31\text{-}32 \times 19\text{-}25\ \mu$.

Sclerotinia heteroica (Wor.). Heteroecism is not confined to the Uredinaceae or rusts, as the present species has been proved by Woronin to be heteroecious. The ascosphores of *S. heteroica* are dispersed by wind, and those that happen to alight on young leaves of *Vaccinium uliginosum* cause infection, and within a short time produce the conidial form of the fungus. These spores are in turn deposited by insects or wind on the stigmas of the flowers of *Ledum palustre*. As a result of this infection a sclerotium is formed in the ovary of *Ledum*. These sclerotia after lying on the ground throughout the winter, produce ascophores, the spores from which infect *Vaccinium* leaves.

Woronin, *Mem. Acad. Imp. St. Petersb.*, Ser. 7, 26, 10 pl. (1888).

Woronin and Nawaschin, *Zeitschr. f. Pflanzenkr.*, 6, p. 129 (1896).

Brown fruit rot.—This is undoubtedly the most destructive and widely distributed of fungus parasites attacking fruit of all kinds belonging to the order Rosaceae. The fungus causing all this trouble has been known until quite recently as *Monilia fructigena* (Pers.), now, however, it has been definitely proved that this same *Monilia* is only the conidial form of a higher ascigerous fungus, and will henceforth, or for some time at all events, be known as *Sclerotinia fructigena* (Schröt.).

The *Monilia* form does all the injury and is the only stage that has up to the present been met with in this country, or

in Europe. The fruit-grower in most instances is only acquainted with the fungus as it occurs on ripe or nearly ripe fruit. As a rule, however, the fungus first appears on the leaves or young shoots; it sometimes also grows on the flowers.

When leaves are attacked the mycelium spreads rapidly in the tissues, and soon gives origin to very thin dark olive-green patches on the surface of the leaf. These patches consist of dense masses of barrel-shaped spores produced in chains. When mature these spores are scattered by various

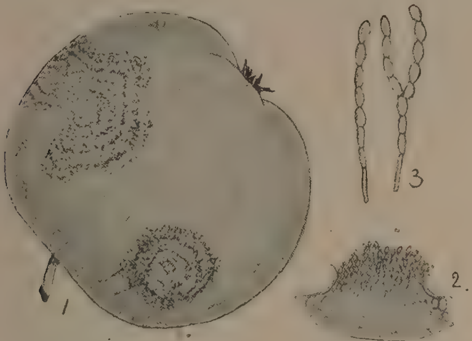

FIG. 80.—*Sclerotinia fructigena.* 1, conidial form (*Monilia fructigena*) on an apple; 2, a pustule of the conidial form; 3, a chain of conidia. Figs. 2 and 3, mag.

means, and infect other leaves, also young shoots and fruit. I have observed the fungus to be especially partial to cherry blossom, where it forms minute velvety tufts on the flower stalk, sepals, and petals, which in consequence turn brown, and eventually die. This effect is usually attributed by gardeners to a touch of frost. On young shoots the fungus also forms velvety olive-brown tufts, but as a rule the twig is not killed the first season. On such infected twigs the mycelium of the fungus survives the winter, and the first spores of the season are often formed on these twigs. These spores in turn infect the young leaves and fruit.

The mode of growth is somewhat different on different kinds of fruit. On apples the fungus fruit is preceded by a brown decayed patch, which soon becomes covered with

greyish-white tufts of fruit arranged in concentric circles. These patches continue to increase in size, and two or more such patches often encroach on each other, and cover the greater portion, or entire surface of the fruit. Such patches are often present while the fruit is still hanging on the tree, and in many instances such diseased fruit does not fall, but remains hanging until leaves appear the following season.

On cherries, plums, peaches, etc., the whitish tufts of fungus fruit are usually irregularly scattered, and not arranged in circles.

In some instances when apples are attacked, no fungus fruit is formed on the surface until the following season, but the skin of the apple becomes tough like parchment, and changes to a black colour throughout.

Woronin has given an excellent and beautifully illustrated account of the *Monilia* stage, and indicated that it was the conidial stage of *Sclerotinia*, but did not discover the ascophore.

Infected fruit does not rot and decay, but gradually dries up and presents a shrivelled or mummified appearance, whether lying on the ground or hanging on the tree. The substance of such fruit is crowded with the mycelium of the fungus, in fact the whole fruit may be considered as a kind of sclerotium, and the spring following its production its entire surface becomes covered with a dense crop of *Monilia* spores.

Norton has met with the ascigerous form of fruit abundantly on mummified plums and peaches that have been lying buried for two years in the orchards in Maryland.

Monilia stage, tufts consisting of simple or branched chains of ovoid or lemon-shaped hyaline spores, $21\text{-}25 \times 10\text{-}12\ \mu$. Ascophore brown 1-2 cm. across, in clusters on buried fruit.

It is very important that all infected fruit, whether hanging on the trees or lying on the ground, should be collected and burned or deeply buried. All dead or cankered twigs should be similarly treated.

When the disease is known to exist, the trees should be thoroughly drenched—also the surrounding ground—during the winter with a solution of sulphate of copper. When the leaves are half grown, spray with a dilute solution of Bordeaux mixture. Norton says that almost all the disease present on peaches followed insect bites or other injury. On plum the disease was very bad, probably following the work of curculio. This suggests that insects favour the entrance of the fungus

into the fruit, and demands an insecticide. Adding Paris green to the Bordeaux mixture should be tried.

Norton, J. B. S., *Plant Diseases in Maryland in* 1902.
Woronin, *Mem. de l'Acad. Imp. St. Petersb.*, Ser. 7, 36.

Sweet chestnut disease.—The leaves and young fruit of the sweet chestnut (*Castanea vesca*) are often injured to a serious extent by a fungus called *Sclerotinia padi*, Wor. (= *Stromatinia padi*, Wor., and *Stromatinia Linhartiana*, Prill. and Del.). The leaves are attacked in the spring, and in rainy weather the disease spreads rapidly. The leaf is usually first attacked near the base of the central vein, and the fungus passes upwards following the vein, extending also on each side of the larger lateral veins. The infected portion soon becomes dark brown, eventually the entire leaf becomes brown and dies. A greyish-white delicate powder appears on the dead patches on the upper surface of the leaf, more especially along the lines of the veins. This is the *Monilia* or conidial form of the fungus. The conidia of the *Monilia* stage are mostly conveyed by insects to the stigmas of the chestnut flowers, where they germinate, grow down the tissue of the style, and destroy the ovules, forming in the place they would normally have occupied, a sclerotium. Fruits that have been attacked are soon killed, and do not decay, but pass into a compact mummified condition, and fall to the ground, and during the following spring give origin to one or more of the ascigerous fruit under the form of a shallow cup supported on a stout stem. Prillieux has proved by a series of carefully conducted experiments that the spores from the ascigerous fruit will give origin to the *Monilia* form of fruit on the leaves.

Ascigerous form. Ascophore cup-shaped, then almost flat, 0·5-1 cm. diam., stem 1-1·5 cm. long, brown, dingy grey, or with a tinge of violet. Asci cylindrical, 8-spored; spores elliptic-oblong, colourless, $12 \times 7\text{-}7{\cdot}5\ \mu$. On mummified fruit on the ground in spring.

Monilia form. Numerous colourless chains of conidia spring from a compact stromatic base, which bursts through the epidermis. The component conidia when free are more or less lemon-shaped.

When the leaves become infected, the fruit also suffers to a serious extent, hence it is important that the spring infection

of the leaves should be prevented as much as possible. There are two distinct means of effecting this. As such infection proceeds from the fungus fruit borne on mummified chestnut fruits, all such should be collected and destroyed. Some such often remain hanging on the tree throughout the winter, and in the spring produce the *Monilia* stage, the spores of which would at once infect young leaves and fruit. The ascigerous condition of the fungus only develops on mummified fruit that has been lying on the ground during the winter. The second protective measure is spraying the trees with Bordeaux mixture when the leaves are young.

Prillieux, *Bull. de la Soc. Bot.*, 39, June 22 and Dec. 9 (1892).
Prillieux, *Malad. des Plantes Agric.*, 2, p. 439 (1897).
Prillieux and Delacroix, *Bull. Soc. Myc. Fr.*, 9, p. 196 (1893).
Woronin, *Mem. de l'Acad. Sci. St. Petersb.*, 1892, p. 17.

Sclerotinia candolleana (Fckl.) occurs on the fallen leaves of sweet chestnut and oak, but in all probability infection occurs when the leaves are living. The ascophores spring from small black sclerotia embedded in the leaf; ascophore brown, 2-4 mm. broad, stem very slender. Spores $7\text{-}9 \times 3\text{-}4\ \mu$.

Sclerotinia curreyana (Karst.) grows in the pith of various species of *Juncus*; the small black sclerotium is embedded in the culm, and bears several small brown ascophores on slender stems. Spores $8\text{-}14 \times 2\text{-}3\ \mu$.

Sclerotinia duriaeaina (Quel.) grows in the culms of various sedges (*Carex*); the small black, elongated sclerotium eventually bears a few ascophores supported on slender stems. Spores $10\text{-}15 \times 6\text{-}8\ \mu$.

Rye grain fungus.—Prillieux has given an account of a remarkable fungus which imparts poisonous properties to the grain of rye. Bread made from such infected rye produces serious effects within two hours, lassitude and absolute incapacity to perform any kind of work for at least twenty-four hours follows: men working out in the fields find themselves unable to return home unaided. The effect on animals that eat the bread is similar to that produced on human beings; they become languid and refuse to eat or drink for twenty-four hours. The effect is not similar to that produced by

ergot, being more intense and rapid, more resembling the symptoms produced by intoxication.

Diseased grains are more or less shrivelled, small, and light, resembling those that have dried up before completing their full development. A section of a diseased grain shows the external portion of the albumen surrounded by a thick layer of mycelium. If diseased grains are placed in a saturated atmosphere, at a temperature of about 15° C., in about fifteen days small tufts of a whitish colour tinged with pink develop on the surface of the grain; these tufts vary from 1-1·5 mm. in diameter. A section shows that these tufts originate from the mycelium inside the grain, and consist of branched filaments, the terminal branches bearing conidia at their summit. The conidia are produced in a very unusual manner, somewhat similar to what occurs in one of the conidial forms of *Thielavia*. The conidia are in reality produced endogenously in the terminal branches of the hyphae, the contents of which becomes broken up into short pieces which become rounded off, clothed in a proper wall, and escape through an opening at the end of the branch, which becomes dissolved. When one conidium has escaped another takes its place, undergoes the same changes, being pushed out of the sheath formed by the wall of the branch by the growth of other conidia lower down in the branch. The conidia are globose, minute, and colourless. At the time it was considered that this structure represented a distinct fungus not previously observed, hence a new genus, *Endoconidium*, was established, and the species described as *E. temulentum* (Prill. and Del.).

Some of the grains of rye that had produced the *Endoconidium* were left under similar conditions for some months, when an ascigerous form of fruit resembling that of *Sclerotinia* appeared on the grains. The apothecia on a single grain varied in number from two to seven. Colour pale fawn, cup concave at first, then slightly convex or wavy, 5-7 mm. diam., stem almost white, 7-10 mm. long. Asci sucylindrical, 8-spored, about 130 μ long; spores elliptic-fusiform, hyaline, $10 \times 4\text{-}5\ \mu$. When the ascigerous form of fruit is produced, the mycelium is found to completely occupy the interior of the grain, but does not form a compact sclerotium as in *Sclerotinia*. Upon this discovery a rechristening became imperative, and the generic name of *Stromatinia* was bestowed, and the fungus became *S. temulenta* (Prill. and Del.), and the

genus *Endoconidium* disappeared as a conidial condition of a higher form of fungus. A similar fate awaits numerous other genera, accepted as such at the present day.

It is suggested that grain grown in a district known to produce the disease should not be used for seed.

Prillieux and Delacroix, *Bull. Soc. Bot. Fr.*, 38 (1891).
Prillieux, *Malad. des Plantes Agric.*, 2, p. 453 (1897).

Gooseberry collar rot (*Sclerotinia fuckeliana*, De Bary) causes a collar rot of gooseberry bushes frequently met with in this country. The bark just above ground, and also for some distance below, becomes soft, water-logged, and finally turns brown and decays, causing the death of the bush. During the summer months the diseased bark is more or less covered with the *Botrytis* condition of the fungus, which resembles a greyish mould. When the dead bark is removed numerous irregularly shaped black sclerotia, 3-6 mm. in length, are to be seen embedded in the tissue of the bark.

Dampness favours the development, as does also the presence of manure or decaying vegetable matter lying on the ground. Deep planting should be avoided.

Smith, *Journ. Bot.*, Jan. 1903.

Tobacco rot.—Prof. Oudemans has described a disease of tobacco plants caused by *Sclerotinia nicotianae* (Oudem. and Koning). Diseased plants have limp, slippery leaves and the stem is discoloured here and there. In some cases the discoloured spots are more or less covered with a delicate white down, or conidial condition of the fungus, and black sclerotia embedded in the down. The disease is very infectious; a single diseased leaf mixed with the healthy leaves to the drying shed quickly infects every leaf with which it comes in contact.

Sclerotia irregular in form, black, up to 10 mm. long, embedded in white mycelium on the stem and leaves, producing up to 20 ascophores; stem slender, flexuous, 4-6 cm. long; ascophore coniform, then expanding, minute, 0·8 mm. diam.; like the stem brown, asci cylindrical, 8-spored; spores elliptical, smooth, hyaline, $5\text{-}7 \times 3\text{-}4\ \mu$.

Conidial form. Conidiophores ascending from creeping hyphae, crowded, stout, apex tapering and bearing a short chain of globose conidia $2{\cdot}5\ \mu$ diam.

The disease is favoured by damp soil and a damp atmosphere, being most abundant near the wind-shelters formed by scarlet-runners. It is recommended that the use of scarlet-runners be abolished, and that French beans be used instead as wind-screens.

Oudemans and Koning, *Konin. Akad. Wetensch. te Amsterdam*, p. 48, June 1903.

PSEUDOPEZIZA (FCKL.)

Ascophore erumpent, sessile, glabrous, minute; asci clavate, 4-8 spored; spores hyaline, smooth, elongated, continuous or 1-septate; paraphyses present.

FIG. 81.—*Pseudopeziza trifolii.* 1, clover leaf infected; 2, fungus bursting through epidermis of leaf; 3, ascus with spores, also two paraphyses. Figs. 2 and 3 mag.

The ascophores originate in the tissues of the host, usually the leaves. Some are parasites, others saprophytes. Distinguished by the ascophore developing in the tissue of the host, and bursting through to the surface at maturity.

Clover leaf spot, caused by *Pseudopeziza trifolii* (Fckl.), is at times very injurious to the clover (*Trifolium*) and

lucerne (*Medicago sativa*), and as the disease spreads very quickly the entire crop usually suffers. The leaves are attacked, the injury first appearing as numerous minute spots which show both on the upper and under surface. At a later stage the ascophores burst through the skin of the leaf under the form of minute pustules or warts.

Ascophores produced in small groups on the upper surface of the leaf, dingy yellow, about 0·5 mm. across; asci clavate, 8-spored; spores hyaline, elliptic-oblong, $10\text{-}15 \times 5\text{-}6\ \mu$; paraphyses rather stout. This fungus has also been called *Pseudopeziza medicaginis* (Sacc.), *P. divergens* (Sacc.), and *Phacidium medicaginis* (Lib.).

When the disease is observed it is advisable to cut the crop frequently; by adopting this method the forage is saved, otherwise all the leaves are lost, and fall to the ground carrying the fungus along with them, thus endangering a future crop. In America diseased fields are burnt over during the winter or early spring. If there is not a sufficient quantity of dead material present, a sprinkling of straw or some dry litter is used. This method removes all dead, infected material lying on the ground. The fungus is parasitic on wild clover, medick, etc., and these are consequently a source of danger.

Currant leaf spot.—This disease was at one time attributed to *Gloeosporium ribis* (Mont.), which was considered as an entity; it is now considered by Klebahn to be nothing more than a stage in the life-cycle of an ascigerous fungus which he has named *Pseudopeziza ribis*. The *Gloeosporium* condition, however, appears able to reproduce itself continually without the intervention of the ascigerous form, which has not yet been recorded in this country.

The *Gloeosporium* stage often does serious injury to the leaves of gooseberries, black and red currants, and also other introduced kinds of *Ribes*. The disease spreads rapidly, causing the leaves to fall early in the season. This not only checks the growth of the fruit already present, but also influences the crop for the following season. The first indication of injury usually appears just about when the leaves are full grown, under the form of small blackish spots, principally on the upper surface; these spots are dense masses of mycelium in the tissue of the leaf, from which originate the spore-clusters that eventually rupture the epidermis of the leaf, allowing minute, oblong, curved spores, $10\text{-}12 \times 5\text{-}6\ \mu$,

to escape in the form of a viscid tendril. The spores forming this filament or tendril are soon liberated by rain from the viscid substance in which they are embedded, and are washed on to other leaves, which in turn are infected.

The ascigerous form of fruit is found in the spring on dead leaves that have been lying on the ground during the winter. The ascophore, like the spore-clusters, originates in the tissue of the leaf and bursts through to the surface at maturity. Spores, 8 in an ascus, broadly elliptical, hyaline, about $10 \times 6\ \mu$; paraphyses clavate.

Dilute Bordeaux mixture or potassium sulphide checks the extension of the disease. Rake together and burn fallen leaves.

Klebahn, 'Unters. über einige Fungi Imperfecti und die zugehörigen Ascomycetenformen,' *Zeitschr. für Pflanzenkr.*, 16, p. 65 (1907).

Alfalfa leaf spot.—Alfalfa (*Medicago sativa*, L.) is subject to many diseases, amongst the worst of which is *Pseudopeziza medicaginis* (Sacc.), which usually forms numerous small brown spots on the leaves, which in consequence soon turn yellow and fall. In some instances, and for some unexplained reason, badly infected leaves show but slight signs of yellowing. The stem is also sometimes attacked, the fungus forming elliptical black spots, 1-3 mm. in length. The lower leaves are attacked first, and when the pest occurs in abundance the crop is much depreciated owing to the loss of leaves, and consequent check on the development of the entire plant.

The fruit does not contain ripe ascospores until the minute cushion-shaped ascophore has ruptured the epidermis. Spores 8 in an ascus, elliptical, hyaline, $8\text{-}11 \times 4\text{-}6\ \mu$.

Stewart states that the disease often appears in fields where alfalfa has not previously been grown. He considers this may be accounted for, in some cases at least, by the land being strewn with soil from infected land, for the purpose of securing inoculation with nodule bacteria. In other instances the spores may be sown with the seed; or finally, the spores may be carried by wind.

Stewart, French, and Wilson, *N. Y. Agric. Exp. Stat., Geneva, Bull.* No. 305, p. 384 (1908).

Pseudopeziza ranunculi (Sacc.). Ascophores in groups or scattered, on the under surface of *Ranunculus repens* and other buttercups. Spores oblong-clavate, at length 1-septate, $15\text{-}16 \times 6\text{-}7\ \mu$.

Pseudopeziza cerastiorum (Fckl.). Gregarious on leaves of various species of *Cerastium*. Spores cylindric-oblong, continuous, $9\text{-}12 \times 3\ \mu$.

Pseudopeziza calthae (Mass.). Gregarious on brown spots on under surface of leaf of *Caltha palustris*. Spores continuous, narrowly elliptic-oblong, $15\text{-}20 \times 6\text{-}8\ \mu$.

Pseudopeziza radians (Sacc.). Gregarious, often forming black patches or straight-radiating or dendritic lines on both surfaces of leaves of *Campanula patula*, *C. rapunculus*, and other species of *Campanula*. Spores continuous, nearly cylindrical, $8\text{-}10 \times 3\text{-}3{\cdot}5\ \mu$.

Pseudopeziza repanda (Sacc.). Gregarious on the under side of leaves of *Galium boreale*, *G. mollugo*, *Asperula odorata*, and other allied plants. Sometimes present on stem also. Spores continuous, narrowly clavate, $10\text{-}13 \times 2{\cdot}5\text{-}3\ \mu$.

It is suspected, but not definitely proved, that a minute fungus called *Placosphaeria stellatarum* (Sacc.) found on living leaves of *Galium* and *Sherardiae*, is a conidial form. Minute black stromata on both surfaces of the leaf, with numerous minute internal cavities containing rod-shaped, hyaline spermatia, $30\text{-}40 \times 1{\cdot}5\text{-}2\ \mu$.

A second form also suspected of affinity, is called *Phyllachora punctiformis* (Fckl.), the spermatia are cylindrical, hyaline, $6 \times 1{\cdot}5\ \mu$.

DASYSCYPHA (Fries.)

Cup minute, nearly or quite sessile, externally pilose or downy; asci 8-spored; spores elongated, hyaline, continuous or 1-septate; paraphyses cylindrical or lance-shaped. A conidial form is present in some species, under the form of minute whitish pustules.

A large genus, most are saprophytes, a few closely allied species are very destructive parasites on conifers. Characterised by the villose or downy exterior of the cup, and by growing on plants.

Larch canker.—This very destructive disease, caused by *Dasyscypha calycina* (Fuckel), in some books called *Peziza*

willkommii (Hartig), is present in greater or less abundance, depending on local conditions, elevation, etc., wherever the larch (*Larix europaea*, D. C.) grows. It also attacks the Scots pine (*Pinus silvestris*, L.), the silver fir (*Abies pectinata*, D. C.), *Pinus laricio* (Poir.), and the Japanese larch (*Larix leptolepis*, Endl.). Until recently it was considered that the Japanese larch grown in this country was immune to this disease; this, however, is not so, as I have seen specimens bearing this disease from England, Scotland, and Wales respectively. In Southern Europe canker occurs on young

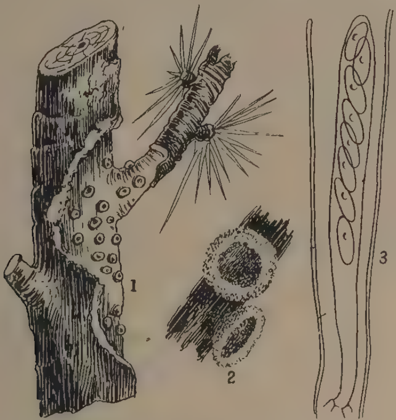

FIG. 82.—*Dasyscypha calycina*. 1, larch branch diseased; 2, fungus causing disease; 3, ascus with spores and paraphyses. Figs. 2 and 3 mag.

branches of the mountain pine (*Pinus pumilio*, Haenke), and the balsam fir (*Abies balsamea*, Miller) suffers from this disease in the United States.

The fungus is a wound parasite, as first indicated by Hartig; this statement I have corroborated by over a hundred experiments on trees of various ages, and situated in different parts of the country. Fresh ascospores, that germinated readily in water, were placed on the bark of young branches, also in crevices of older branches, but no inoculation followed in a single instance, although provision was made against dessication or removal of the spores by rain. Several similar

attempts at inoculation by means of the conidia of the fungus also resulted in failure. On the other hand, inoculation by means of inserting ascospores or minute portions of wood or of resin containing mycelium, into small incisions made in the bark, resulted in the production of canker, on which the fruit of the fungus eventually appeared. I have not succeeded in producing the disease when conidia of the fungus were used as infecting material. The wounds occurring under ordinary conditions, through which infection may take place may be grouped under four headings:—

1. Wounds caused by wind, or by snow resting on branches which in consequence are partly torn away from the trunk.

2. Extrusion of sap caused by late spring frosts.

3. Nibbling of the cortex by insects, rabbits, etc., and more especially punctures made by the larch aphis (*Chermes laricis*, Hartig).

4. Wounds made near the base of the stem, when planting young trees.

As a rule when trees under ten years of age are attacked by canker, they are either killed outright, or so far injured as to be of inferior value if they continue to grow. The reason for this is, in young trees the main stem is usually attacked, whereas in older trees the bark of the trunk is too thick to be punctured by insects or injured by frost. In such cases, as a rule, the branches only are attacked, and the wounds are not serious. The larch aphis is undoubtedly responsible for much of the canker on seedlings and young trees, and perhaps it is not too much to state that if larch aphis was absent, there would be no larch canker to the extent of an injurious epidemic. I have proved by experiment that if a young branch is punctured by inserting the point of a needle, a minute drop of sap oozes out; now if spores of the canker fungus are placed on this drop, infection follows. Similar extrusion of minute portions of sap follow late spring frosts, and as the fungus spores are mature at this season, it is highly probable that infection occurs from this cause on a large scale.

In the case of young trees, canker is often present in abundance on the stem just above the ground-line. This is accounted for as follows by Somerville: 'Not only is infection specially liable to occur low down on a stem on account of the abundance of moisture, but the chances of an outbreak of

disease at such a place are also favoured by the frequent presence of wounds near the surface of the ground. These wounds may be caused by lifting the plants from the nursery beds, or they may be formed by the feet or the tools of the workmen during planting. Where trees are planted by 'notching,' the turf is firmed round the base by the repeated application of the heel of the planter, and in doing so it not infrequently happens that the boot comes in contact with the stem and abrades the bark. And should the plant escape injury during planting, it is still very likely to be injured near the ground by rabbits, hares, voles, and other animals.'

For the reasons already given, the trunks of trees ten or twelve years of age are practically safe against infection except near the top, and there the drier air and exposure to light are safeguards against any serious injury from canker.

The ascophores vary in size from two to five mm.; the disc varies in colour from orange to red, externally pure white and minutely downy or hairy under a lens; spores $18\text{-}25 \times 5\text{-}6\ \mu$, paraphyses longer than the asci. The conidial condition appears before or along with the ascophores under the form of minute dull yellow pustules; conidia globose $1{\cdot}5\ \mu$.

Much has been written as to the cause and means of prevention of canker. It is perfectly certain, unless our knowledge becomes greatly extended, that the fungus causing larch canker cannot be exterminated. In its native habitats the larch grows at a greater elevation than can be offered it in Great Britain. Under those conditions even, canker is present, but not to an injurious extent. The fungus *Dasyscypha calycina* is an alien, and was in all probability introduced to this country along with its host, the larch. It is often argued that because splendid woods of larch have been grown in this country, free from disease, and at a very low altitude, that with proper management such conditions could be repeated. This I am afraid is a serious mistake. Such woods were grown by our forefathers, and before the fungus had become generally distributed. Larch would undoubtedly grow in this country just as well as ever it did, but at low altitudes the fungus, now present everywhere, is dominant; when our forefathers grew their fine larches the fungus had not had time to spread and produce an epidemic. Under the circumstances it is not advisable to plant larch in low-lying, damp situations, and not to plant it anywhere as a pure wood.

The larch is undoubtedly most liable to infection when quite young, and under such conditions, as in nurseries, the fungus spores in the majority of instances gain an entrance through wounds and punctures made by the larch aphis, it is important that the seedlings should be protected against this pest. This can be done by spraying in the spring with the following solution. Dissolve half a pound of soft soap in two gallons of hot water, then add two gallons of paraffin and mix thoroughly until the ingredients do not separate on standing. One gallon of the mixture thus prepared should be diluted with fourteen gallons of water, when it is ready for use.

In larch woods it is not an unusual thing to meet with numbers of dead trees standing, and also branches lying about, covered with the canker fungus cups. All such should be removed and burned, to prevent further infection.

Hartig, R., *Unters. Forstbot. Inst. München.*, 1, p. 63.

Massee, G., *Journ. Bd. Agric.*, Sept. (1092).

Somerville, W., *Trans. Engl. Arboric. Soc.*, 2, p. 363 (1893-94).

Spruce canker.—This disease, caused by *Dasyscypha resinaria* (Rehm.), to the naked eye, or even when examined with a magnifying-glass, is practically indistinguishable from larch canker, caused by *D. calycina* (Fuckel); the structure of the fungus is, however, very different in the two diseases. In this country *D. resinaria* is most frequent on the spruce (*Picea excelsa*, Link); it also occurs on larch (*Larix europaea*, D. C.), and has proved very destructive to the Bhotan pine (*Pinus excelsa*, Wall.) in Wiltshire. On the continent *D. resinaria* has been recorded as a parasite on the spruce fir, and in the United States it does serious injury to *Abies balsamea*, and is thus described by Anderson: 'On some trees (*Abies balsamea*) almost every knot and dead branch was surrounded by one of these canker swellings, the canker not infrequently extending all round the tree trunk or branch. When younger stems or branches were affected in this way the portion above the canker, and often the whole stem, had been killed by the girdling. Infection takes place, as a rule, around the base of the imperfectly self-pruned branches of the lower part of the trunk. At these places the spores gain access to the inner living bark and to the cambium, where they germinate and cause the increased growth of the wood and secondary cortex. Wounds caused by insects and by

hail and by the breaking of the branches by snow and ice, also expose the cambium to fungus spores.'

Like *D. calycina*, *D. resinaria* is a wound parasite, and I have elsewhere shown that it frequently enters through wounds made by another parasitic fungus called *Exosporium*. The spores also germinate on the resin oozing to the surface through punctures made by the larch aphis (*Chermes abietis*, L.) Soon after infection the outer bark breaks away in fragments, owing to the pressure of the rapidly growing inner bark, which becomes hypertrophied. The depression caused by the work of the fungus continues to increase in size, and the edges of the wound become more swollen than in larch canker, and the wound more frequently girdles the branch. The flow of resin is more copious than in larch canker, and large gum-pockets are formed in the wood. Successful inoculations resulting in the production of ascophores on spruce and larch have resulted from placing a fragment of resin containing mycelium into a puncture in the bark. A similar result followed the placing of ascospores in the minute cavity occupied by *Chermes laricis* or *Larix sibirica* (Ledeb.).

The ascophore in *D. resinaria* closely resembles that of *D. calycina*, but is more narrowed below into a stem-like base, and the disc is of a paler yellow colour. The essential character of *D. resinaria* is the very minute, subglobose spores, $3 \times 2\text{-}2{\cdot}5\ \mu$. Conidia elliptic-oblong, $2 \times 1\ \mu$.

Preventive remedies same as for larch canker.

Anderson, A. P., *Bull. Torrey Club*, 29, p. 23 (1902).
Massee, G., *Journ. Board Agric.*, Sept. 1902.

Dasyscypha subtilissima (Sacc.) has been observed forming a canker on the living bark of *Abies pectinata* (D. C.), and on *Larix europaea*, (D. C.), but is not injurious at present.

Ascophore resembling that of *D. calycina*; spores $8\text{-}10 \times 2\ \mu$.

Dasyscypha abietis (Sacc.), parasitic on the bark of *Picea excelsa* (Link.) Ascophore indistinguishable from that of *D. calycina*; spores elliptic, ends acute, becoming 1-septate, $12\text{-}14 \times 3\ \mu$; paraphyses longer than the asci.

SCHIZOTHYRIUM (Desm.)

Ascophores more or less immersed in the substance of the host, opening by a longitudinal slit or by slits radiating from

the centre; asci normally 8-spored, often fewer; spores elongated, hyaline, 1-septate.

Sneezewort leaf spot.—Minute black spots are formed on the living leaves of *Achillea ptarmica* by *Schizothyrum ptarmicae* (Desm.). The spots are circular or elliptical, and expose the disc by an elongated or stellately radiating slit. The asci normally contain eight spores, but frequently not more than two are present. Spores elliptic-oblong or very slightly clavate, hyaline, 1-septate, $10\text{-}14 \times 5\text{-}6\ \mu$; paraphyses slender, branched.

In the spermogonia or conidial form the perithecia are flattened; spores ovate-oblong, hyaline, $10 \times 6\text{-}7\ \mu$.

B. *Spores coloured.*

BULGARIA (Fries.)

Ascophore more or less gelatinous, erumpent, the blackish disc gradually expanding until plane; asci 4-8-spored; spores elongated, continuous, brown.

Distinguished by the large, black, fleshy-gelatinous ascophore.

Beech bark fungus (*Bulgaria polymorpha*, Wetts.) is very common in this country as a saprophyte on dead trunks of beech and oak. It is at times a true parasite on the bark of the same trees. Ludwig considers the *Bulgaria* as a dangerous parasite to the oak. Biffen, who has made a special study of this fungus, finds that the results of its action on oak wood are to dissolve and probably decompose the lignin, and to dissolve the pectates of the middle lamella. No further action was observed, either in pure cultures or in naturally diseased wood, pointing to further action.

Ascophores gregarious, bursting through the bark as scurfy brown knobs about the size of a pea. The disc gradually expands until it becomes almost plane, with more or less of a raised margin, 1-3 cm. across, pitch-black, shining, cutting like a piece of indiarubber. Spores sometimes only 4 in an ascus, and then brown. Sometimes there are 8 spores in an ascus, four brown and four somewhat smaller and colourless, $10\text{-}14 \times 5\text{-}6\ \mu$. Biffen states that the colourless spores

germinate as freely as the coloured ones, and in less time, probably due to the thinner spore-wall.

According to Fuckel ('Symb. Myc.', p. 286) *Tromella foliacea* (= *Ulocolla foliacea*, Brefeld) is a conidial form of *Bulgaria*. This statement, however, has not been corroborated, and should be attended to by those having an

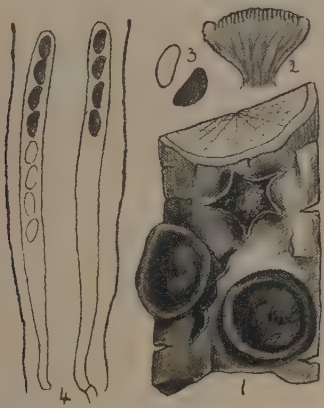

FIG. 83.—*Bulgaria polymorpha*. 1, fungus on trunk; 2, section of same; 3, spores; 4, asci with spores. 3 and 4 highly mag.

opportunity for so doing. Tulasne has also recorded the occurrence of conidial forms of fruit, and so has Brefeld.

Biffen, R. H., *Ann. Bot.*, 15, p. 119 (1901).
Brefeld, O., Heft. 10, p. 301.
Ludwig, *Centralbl. für Bakt.*, 2, p. 521, 3, p. 633.
Tulasne, *Ann. Sci. Nat.*, Ser. 3, 20, p. 164 (1853); *Carpol.*, 3, p. 192 (1863).

KEITHIA (SACC.)

Ascophore immersed in the substance of the host, splitting above by a few irregular teeth; asci containing four spores, which are brown and divided by a septum into two cells of very unequal size.

Juniper leaf spot (*Keithia tetraspora*, Sacc.) forms minute dark spots on living leaves of the common juniper. As a rule only one or two spots are present on a leaf, resembling a *Puccinia* in habit and appearance.

Spores broadly elliptical, clear brown at maturity, divided into two cells of very unequal size, $25\text{-}30 \times 15\text{-}17\ \mu$. Paraphyses pear-shaped and brown at the tip.

ROESLERIA (Thüm. and Pass.)

Ascophore stalked, capitate, hard, apex breaking up and becoming powdery; asci cylindrical, 8-spored; spores globose, coloured.

Growing on the roots of plants underground. The fungus resembles a miniature drum-stick in appearance, being about 3-4 mm. in height.

Vine root fungus.—According to Prillieux serious injury is done to vine roots by a minute subterranean fungus called *Roesleria hypogaea* (Thüm. and Passer.). I have found the fungus on dead rose-tree roots in this country. When the roots are attacked the vine languishes for three or four years, then dies outright. The disease spreads in the soil to neighbouring plants. In many instances where the injury had been attributed to *Phylloxera*, *Armillaria mellea*, or *Dematophora necatrix*, the true cause was found to be due to *Roesleria*, although the general symptoms were similar to injury caused by the other pests enumerated. The mycelium of the parasite attacks all the various tissues of the root, the walls of the woody fibres being curiously corroded by the action of the mycelium.

The fruit of the fungus is only produced on absolutely dead roots. It appears under the form of clusters of slender stems, each bearing a small globose head, the whole resembling a miniature drum-stick. The fungus is not confined to the vine. I have seen it in this country on the dead roots of a rose-tree.

There is much difference of opinion as to whether this fungus is in reality parasitic, or whether it is saprophyte, following on the injury caused by a parasite. Hartig inclines to the latter view, whereas Jolicoeur considers that he proved by experiment the parasitic nature of *Roesleria*.

The entire height of the fruit of the fungus is about 2 mm.,

head white, then greenish brown. Asci cylindrical, soon deliquescing, 8-spored. Spores globose, tinged brown, 4-5 μ diam.

The fungus is most abundant in a very moist soil, especially the subsoil, and drainage is an important factor in checking

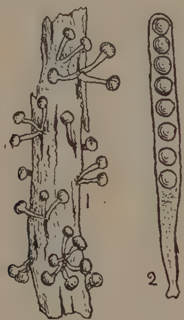

FIG. 84.—*Roesleria hypogea.* 1, fungus on root of vine; 2, ascus with spores. Highly mag.

the pest. Diseased vines should be removed, and the soil treated with lime to check the spread of the fungus in the soil.

Hartig, *Diseases of Trees* (Engl. ed.), p. 83 (1894).

Jolicoeur, *Rap. sur le Malad. de la Vigne, connue dans la Marne sous le nom de 'Morille'*; Châlons-sur-Marne (1881).

Prillieux, *Malad. des Plantes Agric.*, 2, p. 466 (1897).

Viala, *Malad. de la Vigne*, p. 211.

UREDINACEAE

The uredines or rusts are undoubtedly the most pronounced fungal parasites known. There is no single instance recorded of any member of the group having passed through the cycle of its development apart from its normal host-plant. The various species are parasitic on all the higher plants, and their distribution is only limited by that of their hosts. Judging from the extreme nature of their parasitism, the amount of differentiation present, and the dying out in many species of phases of development which remaining

traces prove to have been at one time present, the family appears, relatively to other groups, to be of ancient origin. Many biologic forms are on record.

The great majority of parasitic fungi pass through the entire course of their development on one and the same host-plant. Such are termed *autoecious* species. As opposed to this condition, many species, belonging to the Uredinaceae or rusts, grow during different periods in the cycle of their development on different host-plants. In many instances these different hosts belong to widely separated families; in some instances one host-plant may be a dicotyledon, and the other a monocotyledonous plant, as in the case of the gooseberry cluster-cup fungus, where the aecidium or cluster-cup phase of the fungus grows on the leaves or fruit of the gooseberry, whereas the puccinia or winter stage grows on the leaves of a sedge. Fungi growing at different periods of their development on two different hosts are said to be *heteroecious*, or *metoecious*, as preferred by some. Heteroecism is characteristic of the large genus *Puccinia*, many of the species having four markedly different types of fruit produced during different periods of the cycle of their life-history. In the case of *Puccinia graminis* (D. C.), the earliest spring stage of the fungus develops on young, living leaves of the common barberry. The first indication of the presence of the parasite is the appearance of one or more yellowish blotches, which show at the same points on the upper and under surface of the leaf. Minute flask-shaped bodies, called spermogonia, are the first to make their appearance, sunk in the substance of the blotches on the under surface of the leaf. These flask-shaped bodies, opening by a pore at the surface of the leaf, contain myriads of very minute bodies called spermatia. *Spermogonia* appear to be functionless structures at the present day, and it is surmised that at some earlier period during the evolution of the Uredinaceae, they were male or fertilising organs, the spermatia becoming blended with the trichogne of the female organ, as occurs at the present day in some groups of cryptogams.

Soon following, or contemporaneous with the spermogania, a second type of fruit known as the aecidium stage, popularly known as 'cluster-cups,' appears on the yellow blotch, but on the upper surface of the leaf. The aecidia, when mature, resemble miniature cups with notched and recurved edges

filled with golden yellow spores, called aecidiospores. At this stage the fungus no longer continues to grow on the barberry plant. The ripe aecidiospores are scattered by wind, and those that happen to alight on young wheat leaves or culms germinate and enter the tissues, and within a week or two the third form of fruit, called the uredo stage, appears on the surface of the leaves or culm, under the form of brown streaks, consisting of myriads of minute brown uredospores. This condition is commonly known as the summer stage, as the spread of disease usually entirely depends on uredospores, which are produced in rapid succession during the summer months, and being readily diffused, infect others plants, until frequently the entire crop of wheat is infected. Towards the autumn, when the host-plant is on the wane, the mycelium that had previously produced uredospores, now gives origin to the fourth and last form of fruit, known as the teleutospore stage, known also as the winter or resting-spore stage, because teleutospores require to remain in a passive or resting condition before they are capable of germination. In the spring following their production, teleutospores germinate and give origin to much smaller secondary spores. Such of these secondary spores as happen to alight on young barberry leaves give origin to the aecidium fruit in turn, and thus the cycle of development continues from year to year.

When heteroecism was discovered, it was assumed that the destructive wheat rust, and some other parasites requiring two different hosts for their complete development, could be exterminated by entirely removing from the vicinity one of the host-plants. This surmise unfortunately did not prove to be correct, and it has since been proved that it is not absolutely necessary for the maintenance of a species in time, that it should pass through the entire cycle of its development. In the case of wheat it is known that the aecidium stage can be dropped without checking the development of the parasite. In fact the disease is most injurious in Australia, India, etc., where the aecidium stage is unknown. In many species of rusts one or other of the four forms enumerated above may be missing. The spermogonia stage is unimportant, being at the present day simply a rudiment of bygone times. In other cases, aecidium, uredospore, or teleutospore phase may alone survive, or any two of the three may be present in a species. In some

instances, as in species of *Gymnosporangium*, the two hosts producing aecidiospores and teleutospores respectively, are indispensable for the continuation in time of the fungus, hence the removal of one host arrests the development of the fungus in a given locality.

Aecidiospores are developed in chains, uredospores and teleutospores are borne singly on slender stalks.

Heteroecism, although most pronounced in the Uredinaceae, is not entirely confined to this family. Woronin has proved the occurrence of heteroecism in *Sclerotinia heteroica*, a member of the Ascomycetes. The ascospores of this fungus are produced from a sclerotium developed in the ovary of *Ledum palustre*. The ascospores in turn infect the young leaves of *Vaccinium uliginosum*, which produce a conidial form of fruit. This conidial fruit infects the stigma of *Ledum*, and the ascigerous form is in turn developed.

Woronin and Nawaschin, *Zeitschr. für Pflanzenkr.*, 6, p. 129 (1896).

UROMYCES (Link.)

Spermogonia present in many species; aecidia having the peridium usually well developed; sori of uredospores flat, small; sori of teleutospores more or less powdery, teleutospores 1-celled, with a single germ-pore, stipitate; secondary spores almost colourless, ovoid or elliptical.

Colchicum smut (*Uromyces colchici*, Massee) proved destructive for three seasons in succession to the foliage of a bed of *Colchicum speciosum*, and during the third year the disease spread to *Colchicum bavaricum* and *C. autumnale* that were growing on either side of the diseased batch. Leaves only are attacked, the lowest and oldest leaf first showing the parasite, which follows the leaves upwards in the order of their appearance. The sori are exceptionally large, elongated on the leaf-sheath, often in circular groups on the blade of the leaf. The sori remain for a long time covered by the epidermis, which at length cracks and exposes the black mass of spores. Teleutospores are alone known.

Diseased leaves should not be allowed to rot on the ground, but should be removed before the spores fall; and in the case of diseased plants it is advisable to remove the bulbs to ground that is not infected with spores.

Haricot bean rust.—Haricot beans or 'scarlet-runners' are often attacked by *Uromyces appendiculatus* (Link.) causing the leaves to fall early, when the development of pods is checked. Aecidia, uredo, and teleutospore stages all follow in succession, forming numerous minute brown pustules on the leaves.

Aecidiospores angularly globose, whitish, slightly punctulate, $17\text{-}32 \times 14\text{-}20\ \mu$. Uredospores pale brown, aculeolate, $24\text{-}33 \times 16\text{-}20\ \mu$. Teleutospores elliptical or subglobose, smooth,

FIG. 85.—*Uromyces colchici.* 1, portion of a diseased *Colchicum* leaf; 2, teleutospores, one of which has germinated and produced a promycelium bearing three secondary spores. Fig. 1 reduced, Fig. 2 mag.

dark brown, apex much thickened, with a small, hyaline, wart-like papilla, $26\text{-}35 \times 20\text{-}26\ \mu$.

If the disease appears early, spray with Bordeaux mixture; when the pods are formed, use permanganate of potash.

Broad bean rust (*Uromyces fabae*, De Bary) is a parasite very common on the leaves and stems of broad beans, peas, also on various wild leguminous plants, vetches, etc. The aecidium stage appears in the spring; the cluster-cups are grouped on conspicuous, thickened, whitish spots on the stem and leaves. The uredo stage follows as minute brown pustules, usually scattered thickly over the under surface of

the leaves. Teleutospores are produced from midsummer onwards, as roundish or elongated dark-coloured spots on stem and leaves. The disease is often present in such quantity as to greatly interfere with the yield.

Uredospores subglobose, ochraceous, aculeate, $17\text{-}35 \times 17\text{-}25\ \mu$. Teleutospores ovate or subclavate, smooth, brown, apiculus darker and thickened, $24\text{-}47 \times 17\text{-}30\ \mu$, pedicel hyaline.

A difficult disease to check, as spraying is mostly impracticable. If it is grasped that the disease can only commence in the spring from germinating teleutospores or winter-spores that have passed the winter on old stems and leaves, perhaps all such that are diseased will be collected and burned, instead of being kept, when they are certain to find their way eventually to the manure heap, and thence back to the land, where the spores infect a new crop. Wild vetches should not be allowed to grow in hedgerows, etc.

Carnation rust (*Uromyces caryophyllinus*, Schröter) often injures or even kills cultivated carnations, and usually spreads with great rapidity unless promptly checked. It forms small brown spots on both surfaces of the leaves, which soon curl and die. It is not a native species, having probably been introduced along with plants, and is spread from place to place by the same means.

Uredospores and teleutospores are often mixed in the same pustule or spore-bed. Uredospores aculeate, $40 \times 17\text{-}28\ \mu$. Teleutospores subglobose, apex thickened, $23\text{-}35 \times 15\text{-}22\ \mu$.

Spraying with dilute Bordeaux mixture, if the plants are resting, proves effective. Otherwise sponging with permanganate of potassium must be resorted to.

Beetroot rust (*Uromyces betae*, Kühn) occurs on the leaves of beetroot, sugar beet, and mangold, and when present in abundance, as is usually the case when it once appears, does much injury, checking or completely arresting the work normally accomplished by the leaves, and thus preventing the swelling of the root. The cluster-cup condition appears first in the spring under the form of minute whitish clusters grouped on yellow spots. This is followed by the uredo condition, which usually forms small pustules thickly scattered over the entire surface of the leaf. At a later stage the final teleutospore condition follows, the spores

of which often remain in the dead leaves until the following spring, when they germinate and infect any of the host-plants within reach.

Uromyces betae is very common on wild beet (*Beta maritima*), which is the origin of sugar beet, beetroot, and mangold, and the fungus common on the wild beet has passed on to the various cultivated forms. In addition to this, these cultivated forms, now growing in countries where the wild beet does not exist, are as badly infected with

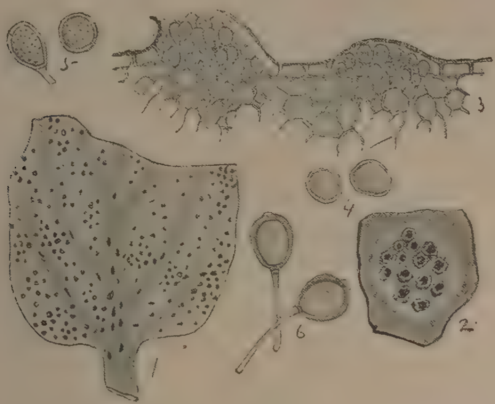

FIG. 86.—*Uromyces betae.* 1, portion of a mangold leaf diseased; 2, portion of leaf with a cluster of aecidia; 3, section of portion of leaf with two uredospore pustules; 4, aecidiospores; 5, uredospores; 6, teleutospores. Fig. 1 reduced, remainder mag.

Uromyces betae as are our European plants. This I consider as one of the proofs that the fungus is by some means carried along with the plants to new countries. Now as beet or mangold is only introduced to new countries by means of seed, it follows that fungus spores must necessarily have been conveyed along with the seed. The disease has already been recorded from S. Africa, Australia, New Zealand, and the United States.

The spermogonia are yellowish in colour and arranged in small, inconspicuous groups. Aecidia whitish with an irregularly fringed margin, small, arranged in circular groups on yellowish patches; aecidiospores globose or broadly

elliptical, smooth, yellow, $20\text{-}26 \times 16\text{-}22\ \mu$. Uredospores forming sori of various sizes, often thickly scattered over the entire under surface of the leaf, for some time covered by the epidermis, elliptical, piriform, or rarely globose, orange brown in the mass, with very delicate spines, or almost, or quite smooth, $20\text{-}35 \times 16\text{-}25\ \mu$, sori of teleutospores dark brown, scattered or in groups, piriform or elliptical, brown, smooth, generally with a colourless papilla at the apex, $25\text{-}35 \times 18\text{-}28\ \mu$, pedicel hyaline, slender.

As the 'tops' of mangold more especially are utilised as food for cattle, etc., it is difficult to convince the farmer that a great risk is incurred when the leaves are diseased. It is yet a more difficult task to induce him to collect and bury all diseased leaves. If such are used for food, or put on the manure heap, it is certain that many of the spores will find their way back to the land uninjured. Nevertheless it pays to do this, and do not plant the same kind of crop on land that has produced diseased plants, for at least two years.

Pea rust.—This is caused by *Uromyces pisi* (De Bary). The aecidium phase of the fungus (= *Aecidium cyparissiae*, D. C.) grows on a spurge—*Euphorbia cyparissias*. The mycelium permeates every above-ground portion of its host-plant, which becomes very much dwarfed in every part, and the substance of the leaves is much thicker than in a normal plant. The mycelium hibernates in the plant. The spermogonia and aecidia are scattered over the entire surface of the leaves. The uredo and teleutospore stages from reddish-brown pustules on the leaves of the cultivated pea, also on those of other leguminous plants, *Vicia cracca*, *V. tenuifolia*, *Lathyrus pratensis*, *L. silvestris*, *L. tuberosus*, etc.

The aecidia are whitish, spores subglobose or polygonal, minutely warted, contents yellow.

Uredospores more or less elliptical, rusty-brown, minutely echinulate.

Teleutospores almost globose, wall minutely punctate, maroon-brown, apex thickened and with a colourless papilla, pedicel slender.

So far as this country is concerned, *Euphorbia cyparissias* is not an indigenous plant, but as an introduction is sparsely distributed. If this plant is removed from the neighbourhood of peas, there can be no danger of infection. The fungus has not been observed in England.

Uromyces striatus (Schröt). The aecidium form of this fungus is parasitic on *Euphorbia cyparissias*, which is dwarfed in a manner similar to that caused by the aecidium condition of *Uromyces pisi*. The uredospore and teleutospore stages infect various leguminous plants, *Trifolium arvense*, *T. agrarium*, *T. minus*, *Lotus corniculatus*, lucerne, etc. The epispore of the teleutospore is marked with fine wavy lines.

PUCCINIA (Pers.)

Spermogonia, aecidia and uredospores as in *Uromyces*; teleutospores transversely 1-septate, each cell having one germ-spore.

Eupuccinia.—Spermogonia, aecidia, uredospores and teleutospores produced on the same living host; teleutospores germinating after a period of rest (not on a living host).

Asparagus rust (*Puccinia asparagi*, D. C.) not infrequently destroys the entire crop of asparagus, but in this country fortunately it is sporadic in its appearance. It has proved very destructive in the United States. It often appears somewhat late in the season when the bulk of the crop has been cut, but, on the other hand, the aecidium form sometimes appears on the youngest shoots. This happens when the crop has been infected during the previous year, and diseased material has been allowed to fall and deposit teleutospores on the ground. The uredo-pustules appear later on the stem and branches; still later in the season the black streaks of the puccinia or teleutospore sori appear, often in such quantity as to blacken the stem and branches.

Aecidia in lines, margin whitish, torn, spores orange, delicately warted, 15-18 μ diam.

Uredopores brown, echinulate, $20\text{-}30 \times 17\text{-}25\ \mu$.

Teleutospores elliptical or elongate-clavate, base rounded, slightly constricted, apex rounded, smooth, brown, $35\text{-}52 \times 17\text{-}26\ \mu$; pedicel persistent.

The only possibility of infection in the spring arises from the presence of teleutospores that were produced the previous year, hence it is of primary importance that all diseased plants be gathered and burned before the teleutospores fall to the ground. After the crop is gathered spray the summer stems with Bordeaux mixture, but cleanliness in removing diseased material and cultivating the ground to bury fallen spores are the most certain preventives against a repetition of the disease.

Mint rust, caused by *Puccinia menthae* (Pers.), often completely destroys entire beds of mint. All stages of the fungus are produced on the same host. The cluster-cup condition of the fungus appears first somewhat early in the season, and is most abundant on the stems, which become much twisted, distorted, and swollen, and more or less covered with the

FIG. 87.—*Puccinia asparagi.* 1, aecidium stage on a young shoot of asparagus; 2, teleutospore stage on a summer plant; 3, aecidiospores; 4, uredospores; 5, teleutospores. Fig. 2 reduced, remainder variously mag.

bright orange spores. The pustules of summer-spores and winter-spores develop at a later stage, and are mostly confined to the leaves, where they appear under the form of minute brown or blackish pustules which soon become powdery.

I. Forming large orange patches on stem and leaves. Spores subglobose, minutely warted, pale yellow, $35\text{-}45 \times 18\text{-}25\ \mu$.

II. Small brown pustules on leaves mostly, spores sub globose or elliptical, pale brown, minutely warted, $18\text{-}28 \times 15\text{-}20\ \mu$.

III. Blackish pustules on the leaves, spores elliptical or almost cylindrical, scarcely constricted, end rounded, thickened, minutely warted, brown, with a pale papilla, $25\text{-}35 \times 18\text{-}23\ \mu$, stem larger than spore.

The mycelium of the aecidium stage is perennial in the creeping underground portion of the stem, hence when a plant is once infected it produces the disease every season.

The only remedy is to dig up and burn all infected plants, which can be recognised early in the season by their distorted stems and small, pale leaves. Care should be taken to remove all the underground portions of diseased plants. Plants from infected beds, even if showing no signs of disease, should not be used for establishing new beds, as they may be infected with spores from diseased plants. It is also important to remember that our wild mints are often badly diseased, and the pest might be introduced to cultivated mint if hay or litter containing diseased wild mint in a dried condition is by any means brought in contact with cultivated mint.

Chrysanthemum rust (*Puccinia chrysanthemi*, Roze) suddenly attacked cultivated chrysanthemums in a wholesale manner some few years ago; it is yet with us, but the sting of its virulence is past, except where there is gross negligence or ignorance. The uredo stage forms numerous small, brown spots on the leaves, and where the fungus is abundant the plant is killed. The teleutospore form is very rare, if known at all in this country.

Uredospores brown, aculeate, $20\text{-}33 \times 18\text{-}25\ \mu$. Teleutospores very irregular in form, often only 1-celled.

The disease spreads rapidly, and keeps itself going from year to year by means of uredospores alone. Diseased plants should be isolated at once, and sprayed at intervals with dilute Bordeaux mixture. Pick off and burn badly diseased leaves. This disease is often imported with plants from the continent, and all such should be carefully examined on their first arrival.

Massee, *Gard. Chron. and Gard. Mag.*, Oct. 8 (1898).

Rhubarb leaf cluster-cups (*Puccinia phragmitis*, Schröt.) sometimes attacks rhubarb, it also occurs on various species of dock (*Rumex*). It causes somewhat large, red, more or less circular patches, at the centre of which are grouped numerous 'cluster-cups' with white, torn margins. The aecidiospores, produced in chains, fill the 'cluster-cups.' The uredospores and the teleutospores grow on *Phragmites communis*.

Aecidiospores (= *Aecidium rubellum*, D. C.), whitish, subglobose, echinulate, $15\text{-}25\ \mu$ diam.

Uredospores forming rather large, dark brown sori, paraphyses absent. Spores ovate or elliptical, brown, echinulate, $25\text{-}35 \times 15\text{-}22\ \mu$.

Teleutospores form large, elongated, black sori. Spores elliptical, ends rounded, much constricted at the septum, blackish-brown, $45\text{-}65 \times 15\text{-}25\ \mu$, pedicel very long, firmly attached.

Onion rust (*Puccinia porri*, Sow.) sometimes proves very destructive to onions, both wild and cultivated; chives are also attacked. Numerous brown, thin, blackish streaks are present on the leaves, which become yellow and die before the bulb is matured. The four spore forms are produced on the same host-plant.

Aecidiospores. Peridia in linear circinate clusters, shortly cylindrical with torn edges. Aecidiospores polygonal from mutual pressure, finely warted, wall colourless, contents orange, $19\text{-}28\ \mu$ diam.

Uredospores. Sori reddish-brown, linear or oblong, in elongated groups. Spores subglobose or shortly elliptical, very finely echinulate, orange-yellow, $25\text{-}30 \times 20\text{-}27\ \mu$.

Teleutospores. Sori small, bluish-grey, owing to the spore-mass being covered by the translucent epidermis of the host-plant; spores clavate or oblong, slightly constricted at the septum, generally narrowed towards the stem, apex rounded or truncate, smooth, brown, $30\text{-}45 \times 20\text{-}26\ \mu$, pedicel hyaline, elongated but not persistent.

Mesospores. Numerous, 1-celled, often very irregular in form, sometimes thickened at the apex, $25\text{-}36 \times 17\text{-}23\ \mu$, pedicel hyaline, deciduous.

This is a very difficult disease to treat. Diseased plants should be removed at once, and the land that has produced a diseased crop should not be sown with onions again for some years, otherwise the teleutospores or mesospores that have fallen to the ground along with decayed leaves will endanger a future crop.

Heteropuccinia.—The secondary spores produced by the teleutospores do not infect the same species of host-plant that produces the teleutospores, but a different one which produces spermogonia and aecidia.

Gooseberry leaf cluster-cups.—During certain seasons the leaves and fruit of the gooseberry are studded with orange blotches, bearing the spermogonia and aecidia or cluster-cups of *Puccinia pringsheimiana*. When expanded the cups have white, torn edges, and are filled with orange spores.

The uredo and puccinia forms grow on the leaves of sedges (*Carex acuta*). Judging from the occurrence of the cluster-cup form on the gooseberry in gardens remote from the habitats of sedges it seems probable that this phase of the fungus can reproduce itself without the intervention of the other stages considered as forming part of its life-cycle.

Aecidiospores globose, epispore hyaline, scarcely wrinkled, contents orange, 10-20 μ diam.

Teleutospores forming elongated sori on leaves and culms, powdery, blackish; spores clavate-oblong or oblong, apex much

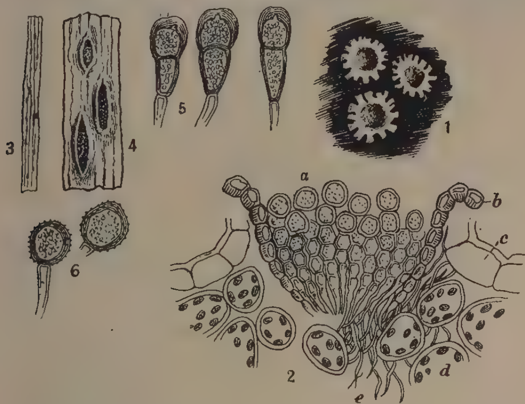

FIG. 88.—*Puccinia pringsheimiana.* 1, portion of gooseberry leaf with three aecidia or 'cluster-cups'; 2, section through a 'cluster-cup'; *a*, spores produced in chains; *b*, wall or peridium; *c*, epidermis of host; *d*, middle cells of leaf; *e*, mycelium of fungus; 3, portion of sedge leaf bearing sori of teleutospores; 4, portion of same; 5, teleutospores. 6, uredospores. Fig. 1 nat. size, and remainder variously mag.

thickened, roundish or truncate, base often narrowed, smooth, brown, 35-50 × 15-20 μ; pedicel rigid, persistent.

No remedial measures known. It is advisable to pick infected leaves and fruit.

Klebahn, *Zeitschr. Pflanzenkr.*, 5, p. 76 (1895).

Black rust of cereals.—This universally distributed rust, caused by *Puccinia graminis* (Pers), is the one most injurious to cultivated cereals, attacking wheat, oats, barley, and rye,

but is most general on wheat. It is also abundant on wild grasses, occurring on one hundred different species in Sweden alone, according to Eriksson.

The spring condition of the fungus, known as the aecidium or 'cluster-cup' stage, grows on the leaves, flowers, and young fruit of the barberry. This condition is accompanied by spermogonia, respecting which but little is known; they are generally considered as representing an effete male element. The aecidiospores are dispersed by wind, and those that happen to alight on the leaf of a wheat plant or other suitable grass, germinate and the germ-tube enters the tissues, and in course of time produces the uredospore or second stage in the life-cycle of the fungus. Uredospores are formed in rapid succession so long as the host-plant remains vigorous, and as these are dispersed by various agents, and infect every wheat plant they alight upon, the disease under favourable conditions spreads rapidly, the epidemic of disease depending entirely upon infection by the uredospore stage of the fungus. Towards the ripening period of the host-plant the pustules that had previously produced uredospores, now give origin to the last phase in the life-cycle of the fungus, viz., teleutospores or resting-spores, which remain in an unchanged condition until the following spring, when they germinate and produce small secondary spores, which infect barberry bushes, when the cycle of development repeats itself. Although the three stages mentioned enter into the entire life-cycle of the fungus, they are not all absolutely essential to its continuance in time. The aecidium stage may be entirely omitted, and it is in the southern hemisphere and on the plains of India, nevertheless the rust of wheat is as rampant as ever. In localities where suitable host-plants live throughout the year, the uredo stage alone is necessary for the continuance of the disease. In many other species of fungi having more than one stage in the life-cycle, it has been proved that one or more stages may drop out entirely, without arresting the development or extension of the species. Dr. Eriksson who has paid considerable attention to the rust of cereals, states that there are at least ten kinds of fungus which cause rust on cereals, some of these are species, others are biological forms. Until recently it was assumed that cereals could be infected by the rust growing on any kind of grass, Eriksson has proved that this assumption is not in accordance with facts, but that many of the rusts on grasses

FIG. 89—*Puccinia graminis.* 1, wheat leaves with uredo pustules; 2, a uredo sorus; 3, uredospores in different stages of development; 4, uredospore germinating; 5, culm of wheat with teleutospore sori; 6, teleutospores in different stages of development; 7, teleutospore that has germinated and produced a germ-tube bearing three sporidiola or secondary spores; 8, barberry leaf with clusters of aecidia; 9, section of an aecidium with chains of aecidiospores; 10, two aecidia; 11, spermatia from a spermogonium. Figs. 1, 2, and 8 reduced, remainder variously mag.

are specialised, or biological forms capable of infecting one, or at most a few allied species. Thus the black rust of oats can infect oats, but not rye, wheat, or barley; crown rust on rye cannot infect wheat, etc. Eriksson has proved that the germination of uredospores and aecidiospores is often small, or at best capricious. The germinating power of teleutospores depends upon certain external conditions, and is restricted to a short period of time, and only the crop of teleutospores maturing during late autumn is able to germinate the following spring. The propagation by spores alone is considered by Eriksson as inadequate to account for the enormous amount of rust appearing simultaneously over very extensive areas. This and other reasons has led the author to the conclusion that, in addition to the ordinary method of infection by spores, there exists in the embryo of the seed, in some form or other, the germs of disease, which under favourable conditions grows up with the young plant, and results in a rusted crop. This idea is generally known as the mycoplasm theory, and is formulated by Eriksson as follows:—

'The fungus lives for a long time a symbiotic life as a mycoplasma in the cells of the embryo and of the resulting plant, and that only a short time before the eruption of the pustules, when outer conditions are favourable, it develops into a visible state, assuming the form of a mycelium.'

This theory has caused much controversy, and was investigated in detail by Professor Marshall Ward, who considered it to be unfounded, and in this country it is generally considered that Ward's investigations proved Eriksson to be wrong. There is one point in Ward's argument which perhaps weakens his supposed refutation of the theory. Eriksson distinctly admits that a certain amount of infection takes place, where the mycelium sends haustoria into the cells of the host. On the other hand, when the mycoplasm present in the cells materialises, Eriksson considers that it does so under the form of minute bodies already in the cells, which send out tubes through the cell-wall and form an intercellular mycelium. Now Ward infected his plants with spores, and of course found haustoria in the cells, connected with intercellular mycelium; these haustoria Ward considered to be identical with the bodies supposed by Eriksson to represent the earliest materialisation of his mycoplasm. This may be correct or it may not, but

it would have been more convincing if Ward had obtained from Eriksson some of the barley which the latter stated to become rusted when grown in sterilised soil, and under conditions that excluded the chance of external infection.

Whether Eriksson's mycoplasm theory proves to be correct or not, I am inclined to believe his idea that spores alone do not account for the enormous and simultaneous appearance of rust over extensive areas under certain weather conditions, and consider that as in the case of rye-grass fungus, potato disease, *Sclerospora* in cereals, etc., the explanation will be found in the form of hibernating mycelium. Dr. Butler, Imperial Mycologist, Simla, India, judging from the following extract, entertains a somewhat similar view:—

'No entirely satisfactory explanation has yet been given of the way in which the disease originates each year. There is strong reason to believe that it cannot arise from spores from the previous crop, nor to any great extent from other grasses affected with the same rusts. No "intermediate" host (bearing the fungus in the aecidial stage) has been found, nor is likely to be found which can commonly produce the disease in the greater part of the infected area. A hereditary origin is possible through the use of infected seed, but is not proved so far as India is concerned.'

Aecidium stage. Aecidia shortly cylindrical, edge spreading and torn; spores subglobose, smooth, yellow, $14 \times 16\ \mu$ diam. Spermogonia on opposite side of leaf to aecidia.

Uredo stage. Sori forming rust-coloured streaks 2-3 mm. long, sometimes much longer; spores broadly elliptic, dingy yellow, spinulose, $17\text{-}40 \times 14\text{-}22\ \mu$.

Teleutospore stage. Sori forming blackish streaks up to 10 mm. long; spores fusiform or club-shaped, with a long pedicel, smooth, chestnut-brown, apex rounded or narrowed, wall thickened, $35\text{-}60 \times 12\text{-}22\ \mu$.

No preventive measures are known, and the production of immune varieties of wheat appears to afford the only hope of preventing loss. Professor Biffen, of Cambridge, has already made substantial progress in this direction.

Butler, *Mem. Dep. Agr. India*, Bot. Ser. 1, No. 2.
Eriksson, *Bot. Gaz.*, 25, p. 26 (1898).
Eriksson and Henning, *Die Getreideroste*, 1896.
Ward, *Ann. Bot.*, 11, No. 6 (1888).

Crown rust of cereals.—A widely distributed rust, caused

by *Puccinia coronata* (Corda), characterised by the apex of the teleutospore bearing a varying number of blunt projections. The aecidia form irregularly shaped yellow blotches on the under surface of living leaves, also sometimes on the flowers and fruit of various species of buckthorn (*Rhamnus*).

The uredo and teleutospore stages usually occur on the upper surface of the leaves, less frequently on the leaf-sheaths, culm, and chaff of wheat, barley, rye, and many kinds of wild grasses. The minute black teleutospore sori often form irregular rings.

Aecidia on irregular yellow patches on the under surface of the leaves, especially along the nerve, also on the flower-buds and fruit. Spores spinulose, $18\text{-}25 \times 14\text{-}19\ \mu$.

Uredo sori orange-red, narrow and elongated, mostly on the upper surface of the leaf, rarely on the leaf-sheath, culm, or glumes; spores globose or broadly elliptical, spinulose, yellow, $20\text{-}32\ \mu$, or $21\text{-}32 \times 20\text{-}24\ \mu$.

Teleutospore sori blackish, small, numerous, often forming rings on the leaf, surrounded by brown paraphyses; spores shortly stalked, mostly clavate, apex truncate, with a variable number of processes of variable length, 25-57 long, basal cell 8-19 μ wide, terminal cell 10-19 μ wide.

Puccinia dispersa (Eriks. and Henn.) forms its aecidium stage on alkanet (*Anchusa arvensis* and *A. officinalis*) as irregularly elongated patches on living leaves, stems, flowers, and fruit. Uredo and teleuto stages on leaves of wheat, rye, and wild grasses belonging to the genera *Bromus*, *Trisetum*, and *Triticum*.

Aecidium stage forming large orange patches on stem, leaves, and calyx; spores spinulose, 20-30 μ diam., or $20\text{-}30 \times 19\text{-}22\ \mu$.

Uredo sori small, 1 mm. long, and nearly as broad, crowded in groups on the leaves, ochraceous brown; spores globose or broadly elliptical, spinulose, yellow, 19-29 μ diam.

Teleutospore sori blackish, irregularly scattered on the under side, rarely on the upper side of the leaf, surrounded by curved brown paraphyses; spores shortly stalked, mostly elongated and club-shaped, unsymmetrical, 40-50 μ long, terminal cell 14-19 μ broad; promycelium colourless.

Puccinia glumarum, Eriks. and Henn. (=*Puccinia rubigovera*, D. C.), is a widely distributed and destructive species, infecting wheat, barley, oats, and many wild grasses. Aecidium stage unknown.

Uredo sori minute, yellow-brown, densely crowded on the leaves, more scattered on the inner surface of the glumes; spores globose or broadly elliptical, spinulose, yellow, 25-30 μ diam.

Teleutospore sori forming crowded blackish streaks on the leaf-sheaths, more scattered on the inner surface of the glumes, encircled with curved, brownish paraphyses; spores unsymmetrical, apex flattened or with 1-2 blunt prominences 30-40 μ long, basal cell 9-12 μ wide, terminal cell 16-24 μ wide; promycelial contents yellow.

Puccinia simplex (Eriks. and Henn.) produces uredo and teleutospores on leaves of barley. Aecidium unknown.

Uredo sori very minute, up to 0·5 mm. long, sparing, scattered on upper side of leaves, citron-yellow; spores globose or shortly elliptical, spinulose, yellow, 19-22 μ diam., or $22\text{-}27 \times 15\text{-}19\ \mu$.

Teleutospore sori very minute, blackish, scattered on the leaves, somewhat longer on the leaf-sheath, surrounded with brown paraphyses; spores stipitate, mostly 1-celled, unsymmetrical, $24\text{-}30 \times 16\text{-}18\ \mu$, rarely 2-celled, clavate, apex blunt or narrowed, 40-48 μ long, basal cell 16-18 μ broad, terminal cell 19-24 μ broad.

Puccinia phlei-pratensis (Eriks. and Henn.) occurs in a wild state on timothy grass (*Phleum pratense*), but artificial infection has shown that it can infect cultivated cereals. The aecidium stage is unknown.

Uredo sori often crowded, yellowish-brown, 1-2 mm. long, on leaf-sheath and culm; spores oblong or pear-shaped, spinulose, dirty yellow, $18\text{-}27 \times 15\text{-}19\ \mu$.

Teleutospore sori blackish, on leaf-sheath and culm, 2-5 mm. long; spores fusiform or club-shaped, constricted at the septum, chestnut-brown, apex rounded or narrowed, wall much thickened, $38\text{-}52 \times 14\text{-}16\ \mu$.

Brachypuccinia.—Spermogonia, uredospores and teleutospores produced on the same host, aecidia absent.

Celery rust (*Puccinia bullata*, Winter) forms small warts on the leaves of celery, parsley, dill, and on several wild umbelliferous plants. When the epidermis is ruptured the spore-mass is brown. The fungus is destructive when present in quantity.

Spermogonia arranged in rounded groups.

Uredospores irregularly globose, aculeate, ochraceous brown, apex thickened, $23\text{-}38 \times 20\text{-}26\ \mu$, with two germ-pores.

Teleutospores often deformed, slightly constricted at the septum, both ends rounded, smooth, brown, apex thickened, $30\text{-}56 \times 17\text{-}28\ \mu$.

Dilute Bordeaux mixture checks the spread of the disease. Diseased leaves should be removed.

Puccinia obtegens (Tub.), better known in this country under the erroneous name of *Puccinia suaveoleus* (Pers.), is exceedingly common on the field thistle (*Cnicus arvensis*, Hoffm.). The mycelium of the fungus hibernates in the rootstock of the host-plant, hence when a plant is once infected it remains diseased for all time. Diseased plants appear earlier in the season than healthy ones, and are readily recognised by the sickly pale green colour of the leaves, which grow upright showing the under surface. No flowers are produced. The spores emit a pleasant odour when the leaves are rubbed between the fingers. As diseased plants do not produce seed, by infecting sound plants, which is readily effected by lashing them with a diseased plant when damp, it should be possible to eradicate one of our worst weeds.

Hemipuccinia.—Uredospores and teleutospores produced on the same host; aecidia and spermogonia absent.

Sunflower rust (*Puccinia tanaceti*, D. C.) forms brown pustules on the leaves of the sunflower (*Helianthus annuus*) and on tansy (*Tanacetum*). The rust is sometimes so abundant as to destroy the foliage.

Uredospores elliptic or ovate, $19\text{-}35 \times 16\text{-}25\ \mu$, minutely aculeate, ochraceous.

Teleutospores elliptical or ovate, apex much thickened, cells almost equal, constricted at the septum, smooth or the apex granulated, chestnut brown, $32\text{-}60 \times 17\text{-}28\ \mu$, pedicel long.

Bordeaux mixture has been proved to check the disease.

Plum leaf rust (*Puccinia pruni*, Pers.) is very prevalent on the leaves of cultivated plum-trees, cherry, peach, apricot, almond, and also on the blackthorn. According to M'Alpine it also occurs on twigs and fruit. The uredo and puccinia stages form numerous small brown spots on the under surface of the leaf, which is often almost entirely covered with the rust. The disease spreads very quickly under favourable

circumstances, and when it occurs early in the year the leaves fall quite early in the season, and consequently the crop is poor in quantity and quality. As a rule the rusts can only attack young growing leaves, but in the present case I have observed a plum-tree seriously attacked during the last week in July. A considerable amount of confusion respecting the

FIG. 90.—*Puccinia pruni.* 1, portion of diseased plum leaf; 2, teleutospore; 3, paraphysis; 4, lower cell and portion of pedicel of a teleutospore, from which the upper cell has broken away; 5, uredospore. Fig. 1 reduced, remainder highly mag.

nature of the various kinds of reproductive bodies produced by this species has existed until recently, when the matter has been thoroughly worked out and put right by Professor M'Alpine.

Uredospores varying from almost globose to piriform, smooth, apex conspicuously thickened, $18\text{-}36 \times 14\text{-}18\,\mu$; paraphyses numerous.

Teleutospores formed of two almost globose, superposed cells, the uppermost largest, brown, warted, pedicel hyaline, elongated; paraphyses numerous.

Spray with dilute Bordeaux mixture at intervals, beginning when the leaves are expanding. It is certain that the first infection in spring is due to the presence of teleutospores, hence all fallen diseased leaves should be dug in, or collected and burned.

M'Alpine, *Ann. Mycol.*, 2, p. 1 (1904).

Puccinia iridis (D. C.) is found on the leaves of many species of iris. The uredospores form crowded pustules. Spores elliptical or ovoid, rough, ochraceous, $20\text{-}35 \times 16\text{-}26\,\mu$.

The teleutospores form long stripes, blackish, spores two-celled, clavate, constricted at the septum, apex thickened, $30\text{-}35 \times 14\text{-}22\,\mu$. No aecidium.

Puccinia gentianae (Strauss) attacks various species of cultivated gentian. The lower leaves are first attacked and

soon become yellow and die, the disease gradually works upwards.

Uredospores subglobose, rough, 22-16 μ.

Teleutospores mixed with uredospores in the same pustules, elliptical, each cell being almost triangular, smooth, brown, 28-38 $\times$ 20-26 μ.

Leptopuccinia.—Teleutospores only known, germinating on the living host.

Hollyhock rust (*Puccinia malvacearum*, Mont.) is a native of Chili, and first occurred as a pest on the cultivated hollyhock in Australia, soon afterwards entering Europe through Spain, and at the present day is in evidence practically wherever the hollyhock is grown. During the first period of the disease, as is generally the case, it was practically impossible to grow hollyhocks, but although yet present, the fungus is not so exacting as it was, and rarely causes a serious epidemic if ordinary precautions are taken. At the present day the parasite has attacked most European wild plants belonging to Malvaceae, the various mallows, etc., also certain cultivated plants, *Abutilon*, etc. This fungus would be a suitable subject for determining whether biologic forms are evolved within a comparatively short period of time. The fungus was first recorded in England in 1873, and it would be interesting to ascertain whether the fungus attacking mallows can infect hollyhocks, and the reverse.

The teleutospore stage is the only one formed, and the spores germinate *in situ*, producing secondary spores which at once infect other leaves or plants, thus spreading the disease after the manner of uredospores in allied species. It has been stated that the teleutospores formed in the autumn act as resting-spores, not germinating until the following season.

Sori forming small, prominent, hard, brown pustules, usually present in considerable numbers on the leaves, sometimes also on the stem, calyx, and fruit. Teleutospores ovoid-oblong, brownish, smooth, slightly constricted at the septum, obtuse or narrowed at the apex, 35-75 $\times$ 12-16 μ, pedicel very long.

I have proved by repeated experiments that if plants of the first year are attacked, they remain free from the disease in spite of attempted infection. On the other hand, if seedlings escape the disease the first year, they are very susceptible the second year. This suggests *similia similibus curantur*, or,

as in other instances, one attack implies immunity in the future.

Pink rust (*Puccinia arenariae*, Wint.) often causes injury to cultivated pinks and carnations. It forms small blackish spots arranged in irregular circles on the leaves and stem.

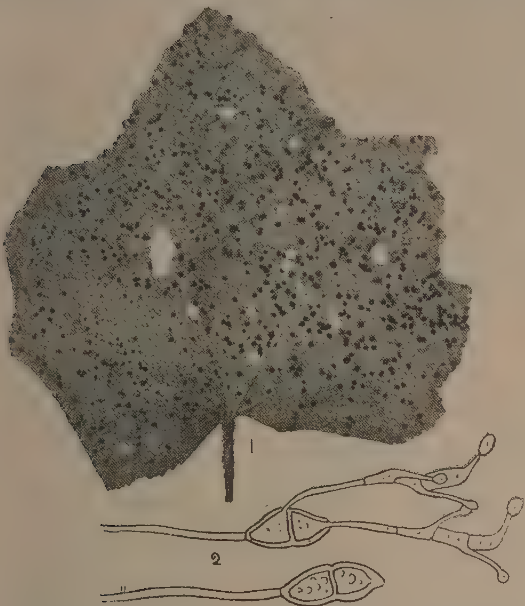

FIG. 91.—*Puccinia malvacearum*. Hollyhock leaf showing pustules of fungus; 2, teleutospores, one germinating. Highly mag.

Teleutospores only are present. These are fusoid or clavate, apex thickened, yellow-brown, smooth, $30\text{-}50 \times 10\text{-}12\ \mu$, pedicel hyaline, about as long as spore.

This fungus is common on many of our wild caryophyllaceous plants, as chickweed, stitchwort, lychnis, etc., hence all such weeds should not be allowed to grow in the neighbourhood of cultivated plants. The directions given under

'Carnation rust' are suitable here. Portions of diseased plants should not be used for propagation, even although they do not show the disease.

Saxifrage rust (*Puccinia pazschkei*, Dietel) once severely injured the foliage of a batch of *Saxifraga longifolia* in Kew Gardens, some of the plants being killed outright. Other species of Saxifrage are attacked on the Continent, and probably the fungus was introduced into this country along with living plants.

Teleutospore sori usually grouped in concentric circles on the upper surface of the leaf, dark brown. Teleutospores elliptic-oblong, rounded at both ends, slightly constricted at the septum, distinctly warted, pale brown, 30-45 × 15-20 μ, pedicel hyaline, slender.

Puccinia saxifragae (Schl.), parasitic on our wild Saxifrages, is distinguished from the above in having the wall of the teleutospore delicately striated instead of warted, and in having a pale apical papilla.

PHRAGMIDIUM (Link.)

Spermogonia flattened, orbicular; aecidia (*Caeoma*) in roundish clusters, confluent, and broadly effused, aecidiospores in chains; uredospores formed singly at the tips of hyphae; teleutospores transversely 3-many-septate, upper cell with 1 germ-pore, remainder with 4 germ-pores.

Rose rust (*Phragmidium subcorticatum*, Winter) is a very troublesome pest to the rosarian, attacking more especially hardy hybrid varieties. It is also common on wild roses. All three forms of the fungus grow on the same host. The aecidium appears first under the form of deep orange, powdery patches on the leaves and young shoots, often causing distortion of the parts affected. At a later stage the patches become deeper orange, owing to the formation of uredospores. Lastly, the teleutospores form minute black dots on the under surface of the leaves.

Aecidiospores orange, aculeolate, 17-28 × 12-20 μ.

Uredospores variable in form, 17-32 × 12-24 μ, delicately aculeolate.

Teleutospores oblong, obtuse, with a white apiculus, warted,

dark brown, 3-8 septate, $75\text{-}100 \times 26\text{-}30\ \mu$, pedicel long, thickened in the middle.

The infection in spring depends entirely on the presence of teleutospores present on fallen leaves, consequently all fallen leaves should be either buried by digging during the winter or by sweeping up and burning. Plants that have

FIG. 92.—*Phragmidium subcorticatum.* 1, rose branch and leaves with aecidium stage of fungus; 2, rose leaf with teleutospores; 3, teleutospores; 4, uredospores. Figs. 1 and 2 nat. size, remainder highly mag.

been attacked should be drenched with a solution of sulphate of copper during the winter.

Raspberry rust (*Phragmidium rubi-idaei*, Winter) produces its three stages on the raspberry plant. The aecidium condition appears first on the upper surface of the leaves in the month of June, under the form of greenish-yellow pustules, usually arranged in broken circles. The uredo stage appears next, and differs but little in appearance from the aecidium;

the pustules are pale orange, and irregularly scattered. Later in the season small black clusters of teleutospores appear on the under surface of the leaves.

Aecidiospores orange, aculeolate, 20-28 μ diam., paraphyses clavate, orange. Uredospores orange, aculeate, 16-22 μ. Teleutospores oblong, apiculate, warted, 5-10 septate, black and opaque, 90-140 $\times$ 20-35 μ, pedicel thickened below.

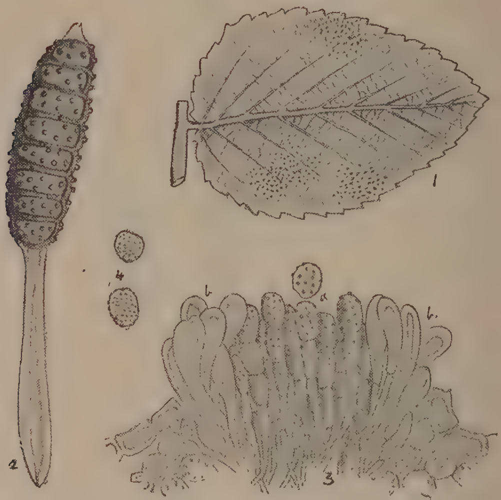

FIG. 93.—*Phragmidium rubi-idaei.* 1, pustules and teleutospores on under surface of raspberry leaf; 2, teleutospore; 3, section through an aecidium; *a*, chains of warted spores; *b*, paraphyses; 4, uredospores. Fig. 1 nat. size, remainder highly mag.

Spraying with potassium sulphide arrests the spread of the disease. If Bordeaux mixture is used it must be diluted, or the foliage will be scorched. Diseased leaves that have fallen should be swept up and burned.

XENODOCHUS (SCHLECHT.)

Teleutospores pedicellate, many-celled, cylindrical, brown, forming large blackish spore-clusters. Aecidiospores in

chains. Closely allied to *Phragmidium*, differing mainly in the relatively greater number of cells forming the teleutospore. Both stages grow on the same host-plant.

Burnet leaf spot (*Xenodochus carbonarius*, Schlecht.) is parasitic on this plant. The aecidium stage forms large, orange-red, roundish patches on the leaves, and elongated patches on the stems. This is followed by the black, wart-like pustules of the teleutospore stage on the leaves. Only met with in this country on *Sanguisorba officinalis*.

Aecidiospores subglobose, yellow, warted, produced in short chains, then becoming free, $15\text{-}25 \times 14\text{-}20\ \mu$.

FIG. 94.—*Xenodochus carbonarius.* 1, teleutospore pustules on Burnet saxifrage, nat. size; 2, a single teleutospore, highly mag.; 3, a chain of uredospores, highly mag.

Teleutospores cylindrical or worm-like, often curved, composed of 10-20 globose cells, much constricted at the septa, smooth or minutely warted towards the apex, dark brown; individual cells 15-20 μ diam.; stalk short, hyaline.

GYMNOSPORANGIUM (HEDW.)

Teleutospores forming large subgelatinous masses, oozing out from the bark of the matrix (always Junipers in this

country); 1-septate, rarely 2-septate, each cell having two or four germ-pores.

Spermogonia and aecidia on a different host to teleutospores. Uredospores unknown.

FIG. 95.—*Gymnosporangium clavariaeforme.* 1, teleutospore stage on juniper branch; 2, teleutospores; 3, teleutospores germinating and producing secondary spores, *a*, *a*; 4, aecidium stage on pear leaf; 5, aecidium stage on branch, leaves, and fruit of hawthorn; 6, aecidiospore germinating. Figs. 1, 4, and 5 reduced, remainder highly mag.

Hawthorn cluster-cups (*Gymnosporangium clavariaeforme*, Jacq.) causes spindle-shaped swellings on the branches of *Juniperus communis*, and during the months of April and May numerous flattened, pale-orange, gelatinous masses

ooze through the bark at these swollen points. The gelatinous masses consist of teleutospores which germinate and produce secondary spores without falling away from the tree. These secondary spores are dispersed by wind, and those that happen to alight on the leaves, young shoots, or fruit of the hawthorn, pear, or whitebeam, set up infection which results in the formation of the cluster-cup stage of the fungus. The cluster-cup spores in turn infect juniper branches, but as the mycelium of the fungus is perennial in the juniper plant, after one infection the teleutospores are produced from the same point each season, at the same time the mycelium continues to spread in the branch, and the swelling becomes bigger each year. On the other hand, there is no perennial mycelium in the case of the cluster-cup, hence the hosts require fresh infection each season.

Aecidia springing in groups from yellow spots, cylindrical, whitish, splitting into recurved shreds, spores in chains, warted, yellowish, $22\text{-}45 \times 19\text{-}35\ \mu$. Teleutospores oblong-fusoid, yellow, $90\text{-}120 \times 15\text{-}18\ \mu$, pedicel very long.

As both hosts are absolutely necessary for the continuance of the fungus, the removal of either host stops the disease, which often causes early defoliation and loss of crop.

Pear leaf cluster-cups (*Gymnosporangium sabinae*, Winter) produces its teleutospore stage on *Juniperus communis*, *J. oxycedrus*, *J. virginiana*, and *J. phoenica*. The gelatinous masses of spores appear in spring on the branches, as flattened, blackish, then reddish-brown masses about half an inch long. So far as at present known the aecidium only occurs on living pear-leaves, where the horn-like aecidia occur in clusters on yellowish spots.

Aecidia up to 2 mm. long, mouth closed, spores escaping through lateral slits, aecidiospores in chains, brownish, irregularly globose, delicately warted, $22\text{-}24 \times 17\text{-}26\ \mu$. Spermogonia present on opposite side of leaf to teleutospores. Teleutospores ellipsoid, chestnut-brown, each cell has 4 germ-pores, $38\text{-}50 \times 23\text{-}26\ \mu$.

When pear leaves are badly infected defoliation takes place early in the season, and the crop is seriously affected. Removal of the infected portions of juniper arrests the disease.

Medlar cluster-cups (*Gymnosporangium confusum*, Plowright) closely resembles the pear leaf cluster-cups in appear-

ance and structure, but differs biologically. The secondary spores produced by the teleutospores will not infect pear-tree leaves, but will infect and give origin to aecidia on leaves of medlar, quince, and hawthorn.

Aecidia on thickened reddish spots on the leaves, cylindric-fusiform, opening by lateral rifts, at length fimbriate, aecidiospores subglobose, pale brown, 15-20 μ diam. Teleutospore masses at first tubercular, dark chocolate-brown, almost black, soon cylindrical, often compressed, becoming rich chestnut-brown; teleutospores smooth, oval or elliptical, ends acute, of two kinds, some orange-yellow, others dark brown with thick walls, $40\text{-}50 \times 20\text{-}25$ μ; pedicel long.

Plowright, *Brit. Ured. and Ustilag.*, p. 232.

Mountain ash cluster-cups.—Teleutospore stage on *Juniperus communis* and *J. nanus*. It is known by the subglobose shape of the soft, gelatinous spore-masses formed in spring, which are dark brown then orange. The aecidium on leaves of mountain ash are cylindrical, curved, soon becoming torn into shreds at the tip. They occur in small clusters on orange-red spots. The name of the fungus is *Gymnosporangium juniperinum* (Winter).

Spermogonia in small groups on orange spots on upper surface of leaf. Aecidiospores in chains, angularly-globose, brownish-yellow, delicately warted, with six germ-pores, $20\text{-}28 \times 10\text{-}24$ μ. Teleutospores ellipsoid or oblong, 1-septate, $40\text{-}75 \times 17\text{-}27$ μ, slightly tinged brown.

Gymnosporangium Miyabei (Yamada and Miyake), a species from Japan, has its teleutospore condition on *Chamaecyparis pisifera* (S. and Z.), and its aecidium form on *Pirus Miyabei* (Sarg.), and *P. aria* (Ehr.), var. *kamaonensis* (Wall.).

Aecidia yellowish-brown, 3 mm. long, aecidiospores irregularly globose or elliptical, 18-21 μ diam., or 24 μ long, on under surface of leaf; spermogonia on corresponding points on upper surface.

Teleutospore masses bursting through bark of twigs, as a crust or warted mass; mostly 2-celled, seldom 3-celled, $36\text{-}80 \times 8\text{-}20$ μ. Promycelium spores $12\text{-}18 \times 7\text{-}11$ μ.

Yamada and Miyake, *Bot. Mag.* (Japan), 22, p. 21, 1908.

CRONARTIUM (Fries.)

Aecidia produced on conifer leaves (so far as known), peridia elongated, aecidiospores in chains. Uredospores produced in a pseudoperidium, brown. Teleutospores 1-celled,

Fig. 96.—*Cronartium ribicolum.* 1, uredo and teleutospore stages on leaf of black currant; 2, uredospores, *a*, and teleutospores, *b*, cemented together in a column; 3, uredospore; 4, teleutospores, two of which are germinating; 5, aecidia on bark of Weymouth pine; 6, aecidiospores. Figs. 1 and 5 nat. size, remainder highly mag.

aggregated into a column which springs from the sorus of uredospores.

Weymouth pine rust (*Cronartium ribicolum*, Deitr. = *Peridermium strobi*, Kleb.).—The aecidium stage of this

fungus appears on living bark of the Weymouth pine (*Pinus strobus*); it has also been recorded on *Pinus lambertiana* and *P. cembro*. The aecidia are large, and burst through the bark in great numbers, eventually opening and exposing a powdery mass of orange spores. These spores germinate readily on living leaves of the black currant (*Ribes nigrum*), and first give origin to numerous sori or pustules of uredospores; from the centre of each uredospore sorus a slender hair-like body develops, about one line long, consisting of an agglutinated mass of teleutospores. At this stage the leaf presents the appearance of being covered with a forest of erect, slender hairs. The teleutospores germinate *in situ*, and produce very minute secondary spores which in turn give origin to the aecidium stage on pine bark, producing spermogonia the first year and the aecidium condition the following season.

Although the Weymouth pine is of American origin, the disease is unknown in that country.

Aecidiospores large, one portion of epispore smooth, remainder warted. Uredospores elliptical or ovoid, orange, aculeate, $19\text{-}35 \times 14\text{-}22\ \mu$. Teleutospores forming a columella 1-2 mm. high, curved, yellowish rufous.

As the fungus requires two hosts for its development, the removal of one of these arrests the disease.

Rostrup, *Bot. Centralb.*, 43, p. 353.

Pine blister-blight (*Cronartium asclepiadeum*, Fries. (= *Peridermium cornui*, Rostr. and Klebh.).

The aecidia appear on the bark of Scots fir (*Pinus silvestris*) late in spring, bursting through the outer dead cortex as irregular, inflated, pale yellow sacs, which open by an irregular crack and liberate the powdery, orange spores. The hair-like, elongated masses of teleutospores springing from the uredo pustules grow on the under surface of the leaves of *Cynachum vincetoxicum*.

Supposed varieties of this species occur on oaks (*Quercus nigra* and *Q. tinctoria*), also on *Comandra umbellata* and *C. pallida* in the United States, also on leaves of *Asclepia speciosa* in France.

Aecidiospores having the epispore partly reticulated and partly warted, $22\text{-}26\ \mu$, rarely $30 \times 16\text{-}20\ \mu$. Uredospores pale orange, echinate, variable in form, $16\text{-}32 \times 12\text{-}18\ \mu$. Colu-

mella of tetraspores up to 2 mm. long, teleutospores oblong, truncate, 12 μ broad.

Prillieux, *Malad. des Plantes Agric.*, 1, p. 271.

Cronartium flaccidum (Winter) forms its uredospores and teleutospores on the under surface of the leaves of cultivated paeonies. The infected leaves present the appearance of being thickly studded with long hairs on the under surface. Aecidial stage unknown.

Uredospores variable in form, pale orange, aculeate. Teleutospores forming a cylindric-oblong, often curved or tortuous column, pale brown, 2 mm. high, teleutospores oblong or cylindrical, ends obtuse, brown, 8-12 μ diam.

Cronartium Comptoniae (Peck), of which the first stage is said to be *Peridermium pyriforme* (Peck), is described as an injurious parasite in the United States by Clinton. The *Peridermium* attacks the Scots fir and pitch pine. The rust occurs only on the stem, and usually near the base, and as the mycelium is perennial, it appears each year, eventually causing the trunk to swell, and injuring the bark and young wood, thereby stunting or even killing young plants. The *Cronartium* grows on the sweet fern (*Myrica asplenifolia*, L.).

Clinton, G. P., *Rep. Conn. Agric. Expt. Sta.* (1907).

ENDOPHYLLUM (Lév.)

Teleutospores 1-celled, produced in chains in a peridium, and resembling aecidiospores in *Puccinia*, but germinating by the formation of a promycelium bearing secondary-spores as in *Puccinia*.

Houseleek rust (*Endophyllum sempervivi*, Alb. and Schw.) is not uncommon as a parasite on the common houseleek and on other species of *sempervivum*. The peridia are embedded in the tissues of the leaves at first, then expand and become broadly cup-shaped with a whitish edge. Infected leaves are longer, narrower, and paler in colour than normal ones. The mycelium is perennial in the host-plant.

Spermogonia appear first, then the teleutospore condition, the teleutospores being produced in peridia like aecidia-spores. Teleutospores subglobose, orange, warted, 1-celled, 20-30 μ. diam.

Diseased plants should be removed, as the mycelium is perennial and they always remain infected, and in addition are liable to infect healthy plants.

PERIDERMIUM (Lév.)

Aecidia growing on bark, cone-scales, or leaves, erumpent, saccate or tubular; spores in chains, globose or elliptical, orange; spermogonia truncato-conoid. Uredospores and teleutospores unknown.

Peridermium harknessi, Moore (=*Peridermium filamentosum*, Peck), often proves very destructive to *Pinus ponderosa* growing on the Sierra Nevada mountains. It attacks the young tree trunks and arrests further growth. The parasite also attacks the following trees in North America; *Pinus insignis*, *P. sabiniana*, and *P. contorta*. Specimens sent to Kew by the late Dr. Harkness, from Sacramento, California, showed that the fungus had first attacked the stem when two or three years of age, and in one specimen the perennial mycelium had continued to grow year by year until the tree was thirteen years of age, when the specimen was collected. During this period of growth the fungus had caused the stem at the point attacked to assume a barrel shape, four inches long and three inches in diameter. The stem just below the swelling was one and a half inches in diameter.

Pseudoperidia crowded, irregular, large, growing all round the branch, aecidiospores irregular in form, orange, at length whitish, 35-40 μ diam., very minutely echinulate.

Peridermium coruscans (Fr.) is common on the spruce in northern Europe, and I have seen it on *Abies pinsapo* in England. The whole of the leaves on a young shoot are attacked, becoming shorter and succulent. Such branches are eaten in Sweden in times of scarcity. The peridia usually occupy the whole length of the leaf, rupturing irregularly and exposing the bright yellow, powdery spores.

Pseudoperidia numerous, longitudinally arranged, at first closed, ellipsoid, then membranaceous, elongated, whitish, tubular, apex divaricating, pale red; spores usually globose, orange-yellow, $30\text{-}35 \times 20\text{-}24\ \mu$, epispore thin, obscurely but very densely verruculose.

Peridermium orientale (Cooke) grows on the leaves of *Pinus longifolia* and *P. excelsa* in the neighbourhood of

Simla. The American forms referred to this species are quite distinct.

Pseudoperidia solitary or scattered, large, for a long time

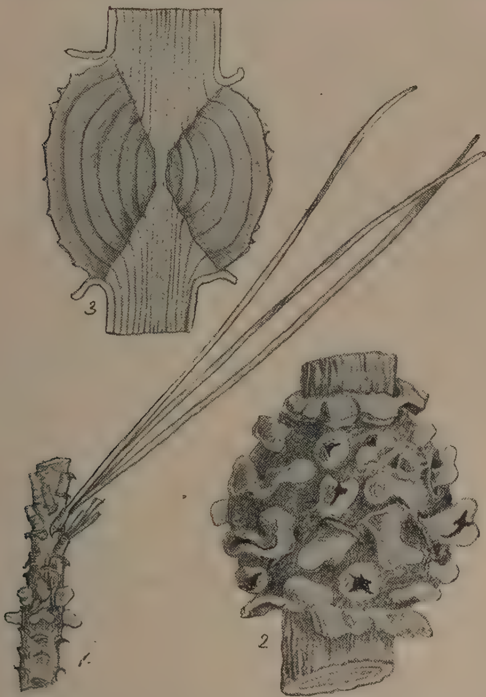

FIG. 97.—*Peridermium Harknessi.* 1, young stem of *Pinus ponderosus*, three years old, showing the *Peridermium*, two-thirds nat. size; 2, appearance of a stem, eight years old, attacked by the fungus, the swollen portion being studded with aecidia, two-thirds nat. size; 3, section through Fig. 2, showing the thickening of the annual rings of wood caused by the presence of the fungus.

closed and triquetrous, at length opening at the apex, orange-rosy; spores subglobose or broadly elliptical, orange, verruculose, $15\text{-}18 \times 10\text{-}12\ \mu$.

Peridermium conorum, Thüm. (=*Aecidium conorum-piceae*,

Rees), forms large aecidia on the outer surface of cone bracts of the spruce—few in number, but not constantly two, as often stated; spores oblong-polyhedric, 24-33 × 18-22 μ, warted, areolate, orange-yellow.

Peridermium giganteum (Mayr.) forms barrel-shaped swellings on the trunk of *Pinus densiflora* and *P. thunbergii* in Japan.

Peridermium thomsoni, Berk. (*Aecidium thomsoni*, Berk.), forms large, elongated aecidia on the leaves of *Picea morunda*, in Sikkim.

MELAMPSORA (Cast.)

Spermogonia forming minute, orbicular, covered patches; aecidia (*caeoma*) destitute of a peridium, spores in chains; uredospores aculeolate, enclosed in a more or less developed peridium; teleutospores 1-celled, wedge-shaped, compacted into a crust-like cushion.

Willow-rod canker.—This disease is caused by *Melampsora alii-salicis albae* (Klebahn). The fungus attacks the rods in the spring, forming wounds up to an inch in length. The bark turns brown and becomes raised in blisters, which finally crack and expose the orange-yellow mass of uredospores. The bark sometimes remains intact for a long time, but if it is broken the orange spores are seen. The rods are very brittle at the diseased points, and are useless for basket-making or other purposes. Later in the season the leaves also bear small powdery patches of uredospores; crust-like, dark-coloured patches of teleutospores also appear on the leaves. The aecidium stage forms small yellow patches on the leaves of various species of wild onion and garlic, as *Allium ursinun*, etc. The uredospore form on the rods is able to perpetuate itself from year to year without the intervention of the other forms.

Uredospores clavate or elongated ovate, warted, 20-40 × 12-18 μ; paraphyses capitate, stalk slender.

Aecidiospores irregularly polygonal, finely warted, 17-26 × 15-18 μ.

Teleutospores brown, 1-celled, cuboid, forming a compact crust under the epidermis.

Removing diseased rods at the earliest period of the disease is the only practical method of checking the disease.

Klebahn, *Zeit. für Pflanzenkr.*, 11, p. 21 (1902).

Pine branch twist.—The aecidium phase of *Melampsora pinitorqua*, Rostrup (=*Caeoma pinitorquum*, A. Br.), has been shown by Hartig to be very destructive to young pines, seedlings being sometimes diseased as they appear above ground. About the age of thirteen the disease dies out, and those that have not been too severely attacked, recover. Plants that are attacked when quite young are usually killed,

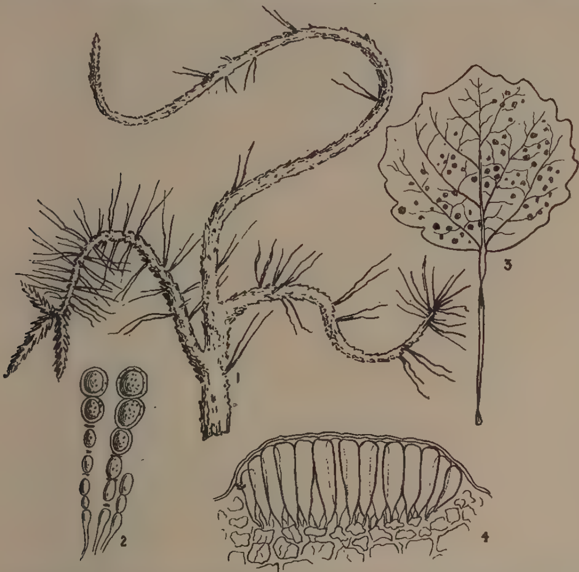

FIG. 98.—*Melampsora pinitorqua*. 1, top of young pine attacked by the aecidium stage; 2, two chains of aecidiospores; 3, aspen leaf with sori of teleutospores; 4, section of cushion of teleutospores, still covered by the epidermis. Figs. 1 and 3 nat. size; remainder mag.

as the fungus appears year after year if damp weather prevails in May and June; this indicates that the fungus is perennial in the tissues of the host.

In the seed-bed or young plantation the disease usually spreads from a centre, due to infection by wind-borne spores, showing that the aecidiospore stage is capable of perpetuating the disease, without the intervention of another condition of the fungus. Spermogonia and aecidia appear on the

leaves and young shoots, the cortex of the latter becoming orange colour. Growth of the branch is arrested at the infected part, whereas growth continues at other parts, and the result of this unequal growth causes the shoot to become more or less curved, and as the tip of the branch tends to grow upwards, double or S-shaped curves are produced.

Rostrup demonstrated by means of inoculation experiments that the teleutospore condition of the fungus grows on aspen leaves, and was at one time called *Melampsora tremulae* (Tul.) The uredospore stage also develops on aspen leaves during the summer, often nearly covering the surface with a yellow powder. The teleutospores appear later when the leaves are dead, and form dark-coloured crusts.

Aecidiospores pale reddish-yellow, subglobose, warted, 15-20 μ diam.

Uredospores elliptic or ovoid, orange, aculeate, 28-38 × 13-20 μ. Paraphyses with the apex swollen.

Teleutospores 40-45 × 13 μ.

Badly-diseased plants should be removed from seed-beds and nurseries. Aspens should not be allowed in the neighbourhood of nurseries.

Hartig and Somerville, *Diseases of Trees*, p. 166.
Prillieux, *Malad. des Plantes Agric.*, 1, p. 286.

Flax rust (*Melampsora lini*, D. C.) sometimes proves injurious to cultivated flax. It is also very common on the little, wild, purging flax (*Linum catharticum*). The uredo stage forms orange-coloured spots on the leaves, sepals, etc., and is followed by the rather large, black, shining pustules of teleutospores.

Uredospores rounded, echinulate, orange, 15-25 × 13-16 μ, paraphyses capitate.

Teleutospores cylindrico-prismatic, polygonal in section, 45 × 20 μ.

A difficult disease to eradicate. Burning material infected with the teleutospores is the only method that can be suggested.

Melampsora repentis (Plow.). Plowright has proved by cultures that the old *Caeoma orchidis* found on *Orchis maculata* is an aecidium form having its uredo and teleutospore forms on *Salix repens*.

Uredospores with minutely spinulose wall, contents orange-

yellow, 10-12 μ diam. Paraphyses hyaline, with large subglobose heads.

Teleutospores cylindrical, polygonal in section, brown, $50\text{-}55 \times 10\ \mu$. Sori yellow, then brown, at last black.

Plowright, *Zeitschr. für Pflanzenkr.*, 1, p. 131 (1891).

Larch leaf rust (*Melampsora laricis*, Hartig, = *Caeoma laricis*, Hartig), during its aecidium stage, forms yellow pustules on larch leaves, causing them to wither and fall. The branches are not attacked. The uredospore and teleutospore stages grow on poplar leaves. It is highly probable that this fungus, also *Melampsora betulina*, are identical with *Melampsora pinitorqua*.

Hartig, *Allgem. Forst. u. Jagd. Zeit.*, 1885, p. 356.

MELAMPSORELLA (Schröt.)

Teleutospore 1-celled, produced in the epidermal cells of the host, confluent in wide, crust-like patches; uredospores echinulate, enclosed in a peridium.

Witches' brooms of silver fir.—The aecidium stage of *Melampsorella caryophyllacearum*, Schröt (= *M. cerastii*, Schröt, and *Peridermium elatinum*, Wallr.), forms cankered swellings on the trunk and branches of the silver fir. From these swollen places witches' brooms often originate, and are readily recognised, even at a distance, by growing quite erect. The leaves on the brooms are small and yellow, and fall about the end of August, being deciduous. Aecidia are only formed on the leaves of the brooms, and not on the swollen portion of the branch, as in other species. The bark is ruptured and thrown off at the cankered swellings, which consequently often serve as a starting-point for wound-parasites, *Polyporus*, agarics, etc.

The uredo and teleutospore stages grow on the leaves and stem of various common caryophyllaceous weeds, *Stellaria media*, *S. nemorum*, *S. holostea*, *Arenaria serpyllifolia*, *Cerastium triviale*, etc.

Aecidiospores elliptical or polygonal, orange, coarsely warted, $16\text{-}30 \times 14\text{-}17\ \mu$.

Uredospores orange, delicately warted, $20\text{-}35 \times 12\text{-}18\ \mu$.

Teleutospores sori often spreading over entire under-surface of leaf, reddish; teleutospores produced in the cells

of the epidermis, subglobose, epispore hyaline, smooth, contents rose-colour, 13-15 μ diam.

Klebahn, *Die Wirtswechselnden Rostpilze*, p. 396 (1904).

HEMILEIA (Berk. and Broome)

Uredo stage forming powdery orange patches; uredospores in small heads or clusters, borne on hyphae emerging through stomata, reniform or subglobose, the whole or only a portion of the surface warted, germ-pores 3-5.

Teleutospores springing from centre of cluster of uredospores, after the latter are fully developed, 1-celled, broadly ovate, umbonate, germ-pore apical.

Aecidium stage unknown.

Characterised from other Uredineae by the mycelium producing the uredospores and teleutospores, emerging through the stomata only, and not pushing through the epidermis.

Coffee leaf disease.—This dreaded disease is in all probability present wherever coffee is cultivated in the Old World. Curiously enough it has not been recorded from the New World, its place being taken by *Sphaerostilbe flavida*, Mass. (=*Stilbum flavidum*, Cooke). The leaves are most frequently attacked, although the young shoots and berries do not escape. On the leaves the earliest indication of the disease is the presence of more or less circular, discoloured spots. These increase in size for some time and become pale yellow, and studded with bright yellow clusters of spores, which soon assume a bright orange colour. The patches show on both surfaces of the leaf, but the spore-clusters are confined to the under surface.

It is somewhat remarkable that no attempt has been made to discover an aecidium condition. Should heteroecism be proved to exist, the fact would be of value in any attempt to check the progress of the disease. Two species, *Hemileia vastatrix* (Berk. and Broome) and *H. Woodii* (Kalchbr. and Cooke), are known as parasites on species of *Coffea*, and as these species are parasitic on several other rubiaceous plants having a widely extended geographical range, their distribution should be carefully studied by those establishing coffee plantations in a district where trees bearing the parasite are present.

Hemileia vastatrix has not been found either on *Coffea arabica* (L.) nor on *C. liberica* (Hiern) when growing wild, which proves that they have originally been infected in a cultivated state by the fungus growing on some other wild plant.

Wild plants producing either *Hemileia vastatrix* or *H. Woodii*, are as follows:—

Ceylon. *Plectronia campanulata* (Beddome), *Coffea travancorensis* (Wight and Arn.).

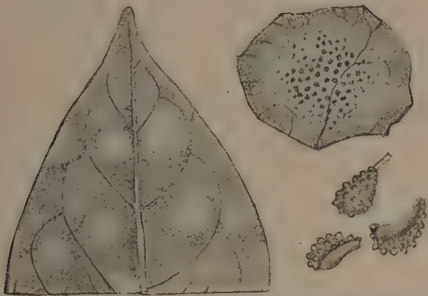

FIG. 99.—*Hemileia vastatrix*. 1, portion of a coffee leaf showing diseased patches; 2, a cluster of sori, slightly mag.; 3, uredospores, highly mag.

China. *Gardenia jasminoides* (Ellis).

Java. *Gardenia*, two undetermined species.

Africa. *Coffea arabica* (L.), var. *Stahlmanii* (Warb.), *Craterispermum laurinum* (Benth.), *Vangueria infausta* (Soud.), *V. euonymoides* (Schweinf.), *V. madagascarensis* (J. F. Gmel.).

Queensland. *Gardenia edulis* (F. Muell.). *Hemileia vastatrix* was recorded by Hennings as parasitic upon *Coffea arabica*, var. *Stahlmannii*, in German East Africa.

The following appeared in the *Gardeners' Chronicle*, March 6, 1909, p. 153, under the heading, 'Disease resistant Coffee': 'A new species, discovered growing wild on the shores of the Oubanghi, Central Africa, by M. Dybowski, and named *C. congensis*, which has been grown since 1903 in the botanical garden at Ivoloina, has so far remained free from disease [*Hemileia*]. Its market value is said to be fully equal to that of the best qualities of Arabian coffee. Whilst the present crop of *C. congensis* has not suffered from the

disease, *C. arabica*, planted at the same time, has been entirely destroyed.'

Uredospore stage. Uredospores forming small groups seated on yellow spots on under surface of leaf, subreniform, triangular in section, free convex surface warted, margined by longer, spinulose warts, the two lateral surfaces, in contact with adjoining spores, smooth, orange, 30-40 × 28-30 μ, pedicel slender, short.

Teleutospore stage. Teleutospores occupying the centre of the heads of uredospores, broadly depressed — ovate, umbonate, smooth, contents orange, averaging 30 × 25 μ.

Hemileia Canthii (Berk. and Broome) is a synonym of this species.

But little appears to have been attempted in the way of spraying as a preventive against an epidemic. In places where the nature of the ground, and other circumstances permit, probably spraying with Bordeaux mixture might be of service. The strength of the mixture would have to be determined on the spot. Judging from analogy, this method should be successful, as the uredospore condition is the one that spreads the epidemic, and this form is produced on the coffee plant.

All diseased leaves should be burned and not allowed to lie about, as the teleutospore or resting-spore stage is also developed on the leaves, and infection might follow.

Hennings, *Zeit. Trop. Landw. Tropenpfl.*, No. 8, 1897, p. 192.

Massee, *Kew Bulletin*, No. 2, 1906.

Ward, *Quart. Journ. Micr. Sci.*, N.S., 22 (1882).

Hemileia Woodii (Kalchbr. and Cooke). This species forms yellow spots on leaves of *Vangueria infausta*, *V. latifolia*, *V. euonymoides*, *V. madagascarensis*, and on *Coffea Ibo* in Africa. On various species of *Gardenia* in Java, and on *Gardenia edulis* in Queensland.

Uredospores forming powdery orange patches, broadly elliptical or subglobose, warted, about 30 μ diam. Teleutospores occupying the centre of the uredospore mass, almost colourless, broadly ovate, umbonate, smooth, about 35 μ diam. The head of spores is surrounded by curved, smooth paraphyses.

Massee, *Kew Bulletin*, No. 2, 1906.

Hemileia americana (Massee). Specimens of the orchid

named *Cattleya dowiana* (Batem.), received at Kew on two different occasions from Costa Rica, have had the leaves suffused with broad patches of a powdery orange fungus, which on examination proved to belong to the genus *Hemileia*.

Uredospores forming broadly effused, powdery, deep orange-coloured patches, uredospores perfectly globose, warted, two germ-pores, 24-32 μ. diam.

Massee, *Kew Bulletin*, No. 2, 1906.

Hemileia oncidii (Griff and Maubl.) is parasitic on leaves of *Oncidium marshallianum*, *O. crispum*, and *O. varicosum*, and has so far only occurred on cultivated plants in France.

The fungus forms powdery orange spots on the under surface of the leaves. Uredospores globose, echinulate, 16-18 μ. Teleutospores springing from the centre of uredospore-sori, subglobose or piriform, at first hyaline, aculeate, then pale brown and almost smooth, $20\text{-}23 \times 15\text{-}20$ μ. Haustoria elliptical or ovate, more or less lobed.

Hemileia indica (Massee). Parasitic on the leaves of an undetermined species of *Macropanax*, from India.

Uredospores forming powdery orange patches, spherical, warted, with a broad circular hilum or point of attachment to the pedicel, about 25 μ diam. Teleutospores occupying the central portion of uredospore head, broadly obovate to subglobose, smooth, 18-20 μ diam.

Massee, *Kew Bulletin*, No. 2, 1906.

Pine cluster-cups (*Coleosporium senecionis*, Fries., = *Peridermium pini*, Wallr.) has its aecidium stage developed on pines. The aecidia are of two forms, one, cylindrical and slender, formed on the leaves, a second, much larger and inflated, appearing in crevices of the bark of *Pinus silvestris*, *P. maritima*, *P. insignis*, and *P. strobus*. The uredo and teleutospore stages form effused orange patches on the under surface of the leaves of groundsel, ragwort, and other species of *Senecio*.

Aecidiospores orange, warted, form variable, up to $40 \times 17\text{-}28$ μ.

Uredospores in short chains, soon free, orange, warted, $20\text{-}40 \times 14\text{-}26$ μ.

Teleutospores forming waxy, reddish-yellow crusts, cylindrical or cylindric-clavate, flattened, generally 4-celled, bright rufous-orange, $110 \times 17\text{-}35$ μ.

Not much injury is done to the leaves beyond local yellow spots; they do not fall before the normal time. When the trunk is attacked the case is different, quite young trees are often killed outright. The mycelium is perennial in the bark, wood, and bast, and extends its area year by year. As a rule the combium is not killed all round the trunk at one point, therefore it continues to grow and produces very eccentric sections, owing to the combium being destroyed on different sides at different levels. Turpentine is secreted in quantity, and escapes through cracks in the bark. As the disease encroaches on the wood, the upward passage of water is checked and the upper branches die, producing the effect known as 'resin-top' or 'resin-leader.' The aecidia burst through the dead bark late in the spring. Hartig considers that infection of the trunk does not take place after the age of twenty-five years.

Hartig, *Wichtige Krankh. d. Waldbäumen.*

CALYPTOSPORA (Kuhn)

Aecidiospores in chains, persistently included in the pseudoperidia; uredospores absent; teleutospores intracellular, generally longitudinally 3-septate, forming brown spore-beds.

Cluster-cup disease of conifers (*Calyptospora goeppertiana*, J. Kühn) possesses two phases in its life-cycle, one of which, the aecidium condition, grows on the leaves of various conifers, *Abies pectinata* (D. C.), and on *A. nordmannia* (Spach.). Infection experiments have proved that the aecidium will also grow on leaves of *Abies nobilis* (Lindl.), *A. magnifica* (A. Murr.), *A. concolor* (Lindl.), *A. balsamea* (Mill.), *A. fraseri* (Lindl.), *A. cephalonica* (Lom.), *A. cilicica* (Ant. and Kotschy), *A. pictita* (Forbes), *A. pinsapo* (Bois.), and *A. vietchii* (Lindl.). On the other hand, *Tsuga canadensis* (Carr.) and *T. douglasii* (Carr.) have resisted all attempts at infection. In conifers the leaves are the part attacked. About a month after infection two rows of white, cylindrical cluster-cups, about half a line in length, appear on the under surface of the leaf; these contain golden yellow spores.

So far as Europe is concerned the teleutospore stage of the fungus is only met with on the cowberry (*Vaccinium vitis-idaea*, L.); it also occurs on *V. myrtillus* (L.), and *V. chandleri*

(Jepson), in the United States. Diseased cowberry plants present a very striking appearance; the stem is the part attacked. All the branches grow perfectly erect; the entire plant grows much taller than healthy plants, and the leaves are stunted. The stem becomes much swollen and spongy in texture, and is at first rosy-pink, changing to brown, then blackish. The teleutospores are produced in the epidermal cells of the swollen portion.

Aecidiospores globose or elliptical, warted, orange, $16-22 \times 10-16\ \mu$. Teleutospores, cuboid-globose, generally 4-celled, brown, smooth, up to $30\ \mu$ long.

If young conifers happen to be growing near to a diseased cowberry plant, the secondary spores from the latter that alight on the conifer leaves set up the aecidium stage, whereas, in turn, the aecidiospores infect neighbouring cowberry plants.

If cowberry plants are growing apart from conifers, the teleutospore stage alone continues to grow and reproduce itself without the intervention of the aecidium stage. On the other hand, the aecidium stage cannot maintain an isolated existence.

The silver fir, in its young condition, suffers most in this country and in Europe. Diseased specimens of *A. nordmanniana* have also been received at Kew from Wales.

Preventive measures are alone of service in combating this disease. In selecting a site for a seed-bed or nursery, it is important to ascertain first that no diseased cowberry plants are growing in the neighbourhood. Such can be readily detected when growing amongst healthy plants from the description given above. The same rule applies when young conifers are planted in woods. If diseased plants are not numerous, they may be removed and burned.

Hartig and Somerville, *Diseases of Trees*, p. 159.
Massee, *Kew Bulletin*, No. 1, p. 1 (1907).

Cinerarea leaf rust.—Mr. F. A. Chittenden has recently described the presence of a rust (*Coleosporium senecionis*, Fr.) on the leaves of *Cineraria*. Infected leaves show small, yellow, powdery patches scattered in greater or less abundance on the under surface. These patches of uredospores are followed by the resting or teleutospore form of the fungus. The aecidium stage, once known as *Peridermium pini*, occurs

in spring on the needles of the Scots fir and other conifers. The aecidiospores infect groundsel and other wild and cultivated species of *Senecio*, and also *Cineraria*, which is botanically a *Senecio*.

Saccardo and others, on the other hand, consider the fungus present on *Cineraria* to be *Coleosporium sonchi* (Lév.). Infection experiments can alone settle this point.

The following is the description of *Coleosporium senecionis*.

Spermogonia scattered; aecidia of two forms, one solitary or few in number, on the leaves, cylindrical, up to 2·5 mm. long; others on the bark, often 6 mm. broad, saccate, crowded, white, becoming torn, spores various in form, up to $40 \times 17\text{-}28\ \mu$, warted, orange.

Uredospores. Sori yellowish-rufous, soon pale, pulverulent; spores in short chains which soon break up, elliptical or sub-cylindrical, orange, warted, $20\text{-}40 \times 14\text{-}26\ \mu$.

Teleutospores forming waxy, compact sori, slightly convex, yellowish-rufous, then red; spores cylindrical, or cylindric-clavate, closely packed side by side, generally 3-septate, bright rufous-orange, apex flattened.

Chittenden, F. J., *Jour. Roy. Hort. Soc.*, 33, p. 511.

Aecidium cinerariae, reported as occurring on leaves of *Cineraria* in Austria, judging from the description, is not likely to be met with again.

CHRYSOMYXA (Unger)

Teleutospores transversely many-septate, arranged in a single series like palisade tissue, sometimes branched, lower cells sterile, coalescing in a waxy convex mass; uredospores as in *Coleosporium*, aecidia as in *Puccinia*.

Rhododendron rust (*Chrysomyxa rhododendri*, De Bary).—The uredo and teleutospore stages develop on the leaves of *Rhododendron hirsutum* and other species, where they form small pustules. The aecidium condition occurs on young shoots and leaves of the spruce fir. Yellow spots appear on the leaves, and about the month of August the spermogonia appear on these spots; at a later period the aecidia are developed, and contain such an immense number of spores that when a diseased tree is shaken, the air is filled with a dense cloud of spores. Diseased leaves die and fall the same season.

Aecidia cylindrical, white, on yellowish spots in one or two rows on the leaves; spores orange-yellow.

Uredospores subglobose, orange, warted, $17\text{-}28 \times 15\text{-}22\ \mu$.

Teleutospores $10\text{-}14\ \mu$ broad, not widened upwards, obtusely rounded.

Not a very injurious parasite. The removal of either of the hosts from the vicinity of each other checks the disease.

De Bary, *Bot. Ztg.*, 1879.
Hartig and Somerville, *Diseases of Trees*, p. 177.

Chrysomyxa abietis (Unger). The teleutospore state only known, forming pale yellow spots on spruce leaves. The formation of the pustules begins during the first year of infection, reaches a certain stage of development, and then passes into a resting condition until the following season, when the development is completed. The teleutospores germinate *in situ* during the month of May, and the secondary spores infect the young leaves.

Teleutospore pustules waxy, reddish-yellow, teleutospores cylindrical, slightly thickened upwards, often branched, up to $100\ \mu$ long, $9\text{-}12\ \mu$ broad, up to 12 cells in a mass.

Causes but little injury.

UREDO (Pers.)

Sori generally orange-yellow, somewhat powdery, pseudoperidium absent; uredospores produced singly at the tips of fertile hyphae.

The species are probably only forms not yet connected with higher stages.

Uredo vitis, Thümen (= *Uredo vialae*, Lagerh.), forms small, yellowish, powdery pustules on cultivated vine leaves, and has been recorded from the United States and the West Indies. Spores piriform or broadly elliptical, verruculose, orange, $18\text{-}30 \times 15\text{-}18\ \mu$, paraphyses curved.

Lagerheim, *Compt. Rend.*, 1890, p. 728.
Massee, *Grevillea*, 22, p. 119 (1893).

Uredo cannae (Winter) is a destructive parasite to cultivated cannas in the West Indies and other parts of the New World. The fungus forms numerous small, orange spots on the leaves,

which become discoloured and soon die. Spores variable in form, yellowish; echinulate, 24-25 × 16-23 μ.

Uredo satyrii (Massee) attacks living leaves of *Satyrium coriifolium* (Swz.) in South Africa. Cultivated specimens of this orchid are destroyed by the fungus. Differs from *Uredo orchidis* (Wint.) in the spore-clusters not being arranged in regular concentric rings, and in the colourless spores.

Spots indistinct; spore-clusters very numerous, mostly epiphyllous; spores globose or ovate, subhyaline, minutely warted, 24-27 μ, or 25-30 × 16-18 μ.

Massee, *Kew Bulletin*, 1809, p. 217.

Uredo tropaeoli (Desm.) forms small, scattered pustules on the under surface of the leaf. Spores powdery, elliptical or rarely globose, orange, 16 × 10 μ. On cultivated species of *Tropaeolum*.

Uredo iridis (Thüm.) forms narrowly elliptical pustules on both surfaces of iris leaves. Mass of spores chestnut colour. Spores almost globose, rarely pear-shaped, rough, brown, 30-35 × 20-25 μ. This is distinct from the uredo form of *Puccinia iridis*.

Uredo quercus (Brom.) forms small rounded pustules, yellowish, then orange, on the under side of the leaves of young oaks. Spores nearly globose, rough, orange-yellow, 15-25 × 12-15 μ

AECIDIUM (Pers.)

Peridium cup-shaped, rarely cylindrical, margin often revolute and torn, aecidiospores produced in chains, subglobose, usually globose.

Pine-cone fungus (*Aecidium strobilinum*, Rees) forms imperfectly developed cluster-cups on the inner surface of the carpellary scales or bracts of cones of the Norway spruce (*Abeis excelsa*). A few cups are sometimes also present on the outer surface of the scales. The mycelium of the fungus destroys the flowers.

The aecidia are brownish, hemispherical, or polygonal from mutual pressure, numerous, and often covering the inner surface of the scales, opening in a circumscissile manner, spores 18-35 × 16-22 μ, epispore hyaline, contents brownish rufous, then paler.

Diseased fallen cones remain spreading open, even in damp weather, whereas the scales of sound cones remain closely compacted together.

Rees, *Die Rostpilzfarmen d. deutsch. Coniferen*, p. 100.

Aecidium phillyreae (D. C.). I observed this fungus infesting every young shoot, also the leaves of a fine large plant of *Phillyrea latifolia* in Pevensey churchyard, Sussex, in August 1907. The shoots were contorted and swollen, and rendered conspicuous by the copious development of orange spores, hence the pardonable mistake on the part of a local scientist in stating that the shrub had bloomed for the first time. On visiting the place the following season it was found that the plant had died during the interval. So far as I am aware there is only one previous record of the occurrence of this fungus in Britain. It is not rare on the continent.

I am quite at a loss to account for the presence of the fungus on this shrub, which had been growing in the same place for twelve years and had never been attacked before. Only the aecidium stage is known to exist; of course this does not prove that a teleutospore stage is not developed, but careful search failed to discover one, or to suggest any host-plant, other than decorative shrubs, likely to harbour one.

Peridia densely crowded, more or less involute, whitish; aecidiospores subglobose or angular, wall colourless, minutely warted, contents orange, 25-35 diam.

Aecidium pseudo-columnare (Kühn). The horn-like aecidia grow in two rows on the under surface of leaves of *Abies pectinata* and other species of *Abies*. Spores whitish, delicately verruculose, 22-37 × 18-26 μ.

Aecidium magelhaenicum (Berk.) grows on species of *Berberis* in South America. The perennial mycelium distorts the buds of the host and causes the formation of witches' brooms. Aecidia usually scattered over entire under surface of leaf, spores 20-40 × 16-24 μ; epispore hyaline, verruculose, contents orange.

Aecidium esculentum (Barcl.) distorts and renders succulent young shoots of *Acacia eburnea*, in India. Spores subcuboid, 28-40 × 16-19 μ.

Aecidium ornamentale (Kalchbr.) sometimes occurs in immense numbers on branches and spines of *Acacia horrida*, at the Cape of Good Hope. The entire structure and general appearance is completely altered by the fungus, the branches

forming fantastic curves. Aecidia fleshy, crowded, pale flesh-colour, spores angularly globose, orange-red.

USTILAGINACEAE

All the members of the present group are obligate parasites. In many instances the spores are produced in the ovary, often on the leaves, sometimes in the anthers. The spore pustules form sooty, black powdery masses when mature, and are

FIG. 100.—Germinating spores of species of Ustilaginaceae. 1, *Ustilago arundinellae*; 2, *Tilletia decipiens*, the secondary spores producing tertiary spores; 3, *Tilletia zonata*. All highly mag. (After Brefeld.)

known as 'smuts' and 'bunts.' Teleutospores only are known in this group.

In some instances infection takes place in the earliest seedling stage of the host-plant, the spores being present in the soil, or adhering to the seed when sown, as in oats. In other instances infection occurs in the flower, spores being deposited on the stigma, and a mycelium is found in the ovary, as in wheat. In maize, on the other hand, infection can take place during any age, so long as young tissue is present. The teleutospores on germination produce a promycelium which gives origin to secondary spores; these in turn often germinate and bear a third form of spore. In *Ustilago* the spores on germination produce minute secondary spores which increase in number by gemmation or budding,

as in the yeasts. This method of increase goes on at an enormous rate in manure heaps, etc., and eventually these minute spores find their way back to the land, in a condition favourable for infecting suitable host-plants.

USTILAGO (Pers.)

Vegetative hyphae spreading in the tissues of the host, soon disappearing; fertile hyphae branched, the spores formed in the interior of gelatinised, clustered, terminal branches; spores 1-celled, on germination producing a short, septate promycelium, which bears minute, lateral, secondary spores.

Loose smut of oats.—This disease, caused by *Ustilago avenae* (Jansen), probably occurs wherever the oat is cultivated, and in this country is known locally as 'smut' or 'slean.' Before preventive methods were discovered it was estimated by Swingle that the annual loss from this fungus in the United States was not less than $18,000,000. The spore-mass or smut is produced in the ovary, and is dispersed by wind and rain before harvest. Brefeld has shown that inoculation can only be effected when the oat is in the seedling state, immediately after germination. Spores adhering to the seed germinate along with the oat, and produce a promycelium, which bears secondary spores, which inoculate the seedling oat, and grow up in the tissue of the plant until the flower is produced, when the fungus forms its spores, in the form of smut in the ovary.

A supposed form of this species, called *laevis*, having smooth spores, has been recorded from the United States growing along with the typical form.

Spore-mass blackish-brown, soon powdery, formed in the ovary; spores globose or broadly elliptical, delicately warted, 6-8 μ, or 7-9 $\times$ 6-7 μ.

Var. *laevis* (Kell. and Swing.), spores smooth and slightly darker in colour than the typical form.

Close has proved by repeated experiments that sprinkling the seed grain with a one per cent. solution of lysol or of formalin in water entirely prevents smut.

Brefeld, *Nachr. aus dem Klub der Landwirthen zu Berlin*, No. 220 *et seq.*

Close, *Year Book U.S. Dep. Agric.*, 1894, p. 414.

Maize smut (*Ustilago maydis*, D. C.) attacks maize or Indian corn, and often seriously interferes with the yield. It forms marked deformations on practically every part of the plant, under the form of large galls or blisters of a whitish colour. When approaching maturity the spore masses appear

FIG. 101.—*Ustilago avenae.* 1, a 'smutted' ear of oats; 2, spores; 3, germinating spores; 4, secondary spores conjugating. Figs. 2-4 highly mag.

to be of a dark olive-green colour, as seen through the tissues forming the membrane. When mature the blisters burst and liberate a dense powdery mass of black spores. The heads are most frequently attacked, and the galls may attain to the size of an apple, sometimes larger. Infection may occur at any young, growing portion of the plant.

The spores are irregularly globose, dark brown, delicately spinulose, 9-12 μ diam.

The early removal of the smut-galls before the spores are mature checks the spread of the disease. When the grain is suspected of harbouring spores it should be treated with formalin before sowing. Fresh manure should not be used, as if spores are present in it and produce conidia, the growing plants may be infected.

Brefeld, *Unters. Gesammt. Mykol.*, 4, p. 11.
Knowles, *Journ. Mycol.*, 4, 1889.
Tubeuf and Smith, *Diseases of Plants*, p. 279.

Covered smut of barley (*Ustilago hordei*, Jensen) attacks the ears of cultivated barley; the spore-mass, instead of becoming powdery and sooty as usual, remains very hard and persistent, being surrounded by the unbroken wall of the grain, and frequently remains so after harvest. Spores subglobose, blackish-brown, 6-7 × 5 μ.

The plant is not infected in the seedling stage, hence it is no use treating the seed. Infection takes place during the following stage, and the grain becomes infected, but shows no sign of injury. Such seed if sown produces a smutted crop. Clean seed, grown in a district free from smut, should be sown.

Loose smut of barley (*Ustilago nuda*, Jensen) also attacks barley; it is distinguished from *U. hordei* by the spore-masses becoming powdery and sooty, and dispersing as soon as mature.

Spores elliptical to globose, soon free and powdery, olive-brown, 5-7 × 5-6 μ.

Preventive means same as those recommended for covered smut of barley.

Loose smut of wheat (*Ustilago tritici*, Jensen) attacks the grain and chaff of wheat, destroying the whole, and forming a loose sooty mass which is dispersed before harvest, as infected plants develop more rapidly than sound ones. Spore mass not fœtid. Spores subglobose or elliptical, pale olive, minutely warted, 5·5-7 × 5-6 μ. Var. *foliicola* (P. Henn.) grows on the leaves and leaf-sheaths of wheat, and is not uncommon in Egypt; spores yellowish olive-brown, 4·5-7 × 4·5-6 μ.

In this case the plant is not infected in the seedling stage, hence the treatment of the seed is of no avail. Infection occurs during the flowering stage, and mycelium is formed in

the seed, which, however, shows no sign of disease, but when sown produces a smutted crop. Seed should be sown that was produced in a crop free from smut.

Scilla smut (*Ustilago Vaillantii*, Tul.) occurs very commonly in the anthers and ovary of *Scilla bifolia* and other

FIG. 102.—Ear of barley attacked by *Ustilago hordei*.

species; *Gagea lutea*, also in species of *Muscari*, *Bellevalia*, etc. The mycelium of the fungus is perennial in the stem or cushion of the bulb, and from thence passes up the flower-stalk and into the anthers or ovary each year; hence when a plant is once infected it remains so for all time, and it is advisable to remove such bulbs, as the flowers are unsightly

when smothered with the sooty mass of spores, which endanger neighbouring healthy plants. Spores variable in form, subglobose, oblong or elliptical, 8-16 × 7-14 μ, brown, smooth, or minutely granulated.

Bamboo smut (*Ustilago Shiriana*, Henn.) attacks a large kind of cultivated bamboo (*Phyllostachys*) in Japan; wild kinds are also attacked. The injury caused is considerable, the internodes and tips of the younger shoots being attacked, often commencing under the young leaf-sheaths.

Spores subglobose or ellipsoid, smooth, 4-7 × 3·5-6 μ.

Spraying with Bordeaux mixture, and sprinkling the soil with lime before the shoots appear, has proved to be of service.

Hori, S., *Bull. Imp. Centr. Agr. Sta. Japan*, 1, p. 72 (1905).

Ustilago sorghi (Pass.) forms spore-masses in the ovary of *Sorghum vulgare* and *S. saccharatum*, filling it with a dusty, sooty mass of spores. The anthers are also infected, and as a rule all the flowers in a head are infected.

Spores globose or irregular, smooth, pale olive, 5-9·5 × 4·5-5 μ.

Ustilago reiliana (Kühn) attacks *Sorghum vulgare* and *S. halapense* in different parts of the world. The ear is attacked, the spore-masses roundish or elongated, at first enclosed in a silvery-white membrane, then powdery and soon dispersed, leaving only the more durable parts of the ear as a skeleton. Brefeld states that the spores germinate after being kept for eight years. The secondary spores also, if kept dry, retain the power of germination for some time. Spores brown, delicately echinulate, 9-12 μ.

Ustilago cruenta (Kühn) attacks the top of the culm and inflorescence of *Sorghum vulgare*, forming reddish-brown patches and causing much distortion of the parts attacked. Spores subglobose, olive-brown, smooth, 5-12 × 5-9 μ.

Ustilago sacchari (Rabenk.) attacks the leaves of the sugar-cane, more especially the upper ones while yet unexpanded, and embracing each other, the whole being converted into a projecting, discoloured, twisted spike. Spores angularly globose, brown, smooth, 8-18 μ.

Ustilago emodensis, Berk. (= *Ustilago treubii*, Solms. Lau-

bach), distorts *Polygonum chinense* in Java and India, forming clustered outgrowths up to one inch long, longitudinally wrinkled and capitate, the violet spore-mass being formed in the swollen head of the outgrowths. Much hypertrophy and modification of the structure of the host occurs at the diseased parts. Galls are also sometimes formed in the inflorescence. Spores violet or lilac, smooth, globose or broadly elliptical, 5-6 μ diam.

Berkeley, *Hook. Journ. Bot.*, 3, p. 202 (1851).
Solms. Laubach, *Ann. Gard. Bot.*, *Buitenzorg*, 6, p. 79 (1887).

Ustilago esculenta (P. Henn.) causes considerable distortion or swelling of the stem of *Zizania latifolia*, and the diseased portions are sold as a vegetable in the market at Hanoi, Tonkin. In Japan it is sold in the apothecaries' shops under the name of Zizania (root-charcoal). The dark spores are used by those having thin eyelashes to make them look darker, and mixed with oil they are used by women having thin or grey hair. The spores are also much used in Japan in the lacquer industry to produce rust-coloured ware when mixed with lac.

Spore-mass olive brown, forming spherical or elongated tubercles. Spores subglobose, $7\text{-}9 \times 6\text{-}8$, brown, smooth.

Hennings, *Hedw.*, No. 34, p. 10 (1895).
Miyabe, *Bot. Mag. Tokio*, 9 (1895).

Ustilago microspora (Massee and Rodway) attacks the inflorescence of *Danthonia penicillata* (F. Muell.). The entire inflorescence is destroyed by the fungus, which is remarkable for the minute, pale olive, glabrous spores, $3\text{-}4 \times 2{\cdot}2\text{-}5\ \mu$.

Only known from Tasmania.

Massee, *Kew Bulletin*, 1901, p. 160.

Ustilago violacea (Fuckel) is produced in the anthers of *Silene inflata*, and many other kinds of caryophyllaceous plants.

Spores lilac, subglobose, wall with an irregular network of raised lines.

Several other wild plants have the anthers infected with species of *Ustilago*.

CINTRACTIA

This genus differs from *Ustilago* only in the spores adhering loosely in clusters when mature.

In reality not a good genus.

Cintractia patagonica (Cke. and Mass.) was the name given to a fungus received at Kew many years ago, parasitic on *Bromus unioloides* and *Festuca bromoides* from Patagonia and Bahia Blanca. Some time ago an English traveller in South America observed that *Bromus unioloides* was grown mixed with lucerne for fodder. Seed of the *Bromus* was brought home, sown, and in due course produced not only fruit, but also its parasite, the *Cintractia*. It will be interesting to know whether host, or parasite, or both, can establish themselves in this country. There are plenty of native species of *Bromus* and *Festuca* to select from.

This is significant in connection with the importation of parasite along with host from one country to another.

Massee, *Gard. Chron., Jan.* 3, p. 14 (1903).

TILLETIA (Tul.)

Spores isolated, formed by the swelling of the tips of fertile hyphae, forming a powdery mass at maturity; promycelium bearing a terminal cluster of elongated, cylindric-fusiform, secondary spores, which after conjugating in pairs *in situ*, either give origin to a curved sporidium or emit a delicate germ-tube.

Stinking smut of wheat (*Tilletia tritici*, Winter, = *Tilletia caries*, Tul.) often proves very destructive to the wheat crop; the plant is infected in the seedling condition, the fungus growing up in the tissues of the host without any external evidence of its existence, except imparting a deeper tinge of green to the leaves, until the wheat is in flower, when the rigid erect ear and spreading florets and glumes betray the presence of the parasite. The spores are formed in the grain or ovary, and, as a rule, every grain in the ear is diseased. When an infected grain is crushed, the powdery blackish-olive mass of spores possesses a very strong smell, somewhat resembling stinking fish, especially when moistened.

Spores globose, brown, 17-22 μ, border 1-1·5 μ, not paler, epispore with raised ridges anastomosing to form an irregular network.

The formalin method, recommended for loose smut of oats, is effective in destroying spores adhering to the seed.

FIG. 103.—*Tilletia tritici*. 1, ear of wheat diseased; 2, spore; 3 and 4, spores germinating and producing a germ-tube, bearing a cluster of secondary spores at its apex; 5, two secondary spores that have conjugated or become united by a short transverse neck; one of the secondary spores has produced a conidium. Figs. 2-5 highly mag. (Figs. 3-5, after Brefeld.)

Wheat sown in the spring is always more smutted than when sown in the autumn.

Brefeld, *Unters. aus dem Gesamn. der Mykol.*, 5, p. 146.

Tilletia levis, Kühn (= *Tilletia foetens*, Arthur), develops in the ovary of wheat, like *T. tritici*, which it resembles in

appearance and smell, but is distinguished by having perfectly smooth spores.

Spore-mass formed in the ovary, deep brown with an olive tinge, foetid; spores globose, elliptical, etc., variable in form and size, pale olive—brown or sometimes almost cream-colour, smooth, 17-21 μ, or $15\text{-}26 \times 10\text{-}15\ \mu$.

Tilletia decipiens, Winter (= *Tilletia secalis*, Kühn), is produced in the ovary of rye, also in several wild grasses. Spore-mass blackish-brown. *Agrostis pumila* (L.) is nothing more than *Agrostis vulgaris* dwarfed by this fungus.

Spore-mass formed in the ovary, blackish-brown, foetid; spores globose, angular, or elliptical, clear brown, with raised ridges anastomosing to form a network of irregular, small meshes, 20-27 μ diam.

Tilletia corona, Scrib. (= *T. horrida*) attacks the grain of rice (*Oryza sativa*, L.), which becomes filled with a black mass.

Spores dark brown; warted, 22-26 μ diam.

This smut also attacks species of *Homalocenchrus* and *Panicum*.

Anderson, A. P., *Bot. Gaz.*, 27 (1899).

UROCYSTIS

Sori erumpent, large, black, powdery; spore-clusters consisting of one or more central, fertile, dark-coloured cells, surrounded by smaller, pale-coloured, sterile, peripheral cells.

Rye smut (*Urocystis occulta*, Rab.) is most abundant on rye, but also occurs on wheat and barley, and according to Wolff it attacks wheat in Australia. It forms long grey lines on leaf-sheaths, leaves, and upper part of the culm. The streaks become black and powdery, the tissues are more or less destroyed, and the ear is arrested in its development. The culm often bends over and breaks at the point attacked.

Spore-clusters $17\text{-}24 \times 15\text{-}20\ \mu$, central ones dark brown, sterile ones pale, forming a broken zone round fertile ones.

Treating the seed with formalin, as recommended for *Ustilago avenae*, has proved satisfactory.

Prillieux, *Malad. des Plantes Agric.*, i. p. 187.

Onion smut (*Urocystis cepulae*, Frost) is only known to attack cultivated onions, and develops during the seedling stage. As a rule the first leaf shows the disease before the second leaf appears: the disease attacks the leaves in the order of their appearance. The outer coat of the bulb is

FIG. 104.—*Urocystis occulta.* 1, upper part of rye plant diseased; 2, spores, one of which has germinated and produced a cluster of secondary spores at the apex of the germ-tube; 3, a spore that has germinated and produced secondary spores, two of which have germinated. Figs 2 and 3 highly mag.

also attacked. The fungus bursts through the epidermis as large, black, powdery streaks.

Spore-clusters 18-25 μ diam., usually only one, brown, central, fertile cell, surrounded by many pale, sterile cells.

White varieties are most susceptible to the disease. Infection occurs during seedling stage by spores in the soil. It

is recommended that onions should be transplanted, because at a certain age the plants cannot be infected, even if spores are in the ground. Diseased plants should be collected when thinning is in operation.

Thaxter, *Ann. Rep. Conn. Expt. Stat.*, p. 129 (1890).

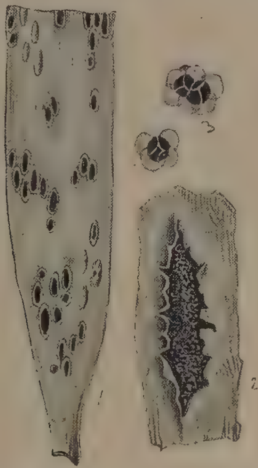

FIG. 105.—*Urocystis colchici.* 1, portion of infected leaf; 2, a single sorus, slightly mag.; 3, spores, highly mag.

Colchicium smut (*Urocystis colchici*, Rab.) forms long rows of black, powdery streaks on the leaves of colchicum—*Colchicum autumnale*, *Muscari racemosum*, *M. comosum*, *Scilla bifolia*, *Allium rotundum*, *A. cepa*, *A. magicum*, and *Paris quadrifolia.*

Spore-clusters globose or oblong, 20-33 × 16-20 μ; central fertile spores chestnut-brown, sterile peripheral cells pale yellowish-brown, small.

Gladiolus smut (*Urocystis gladioli*, Smith) sometimes attacks the corms of cultivated kinds of *Gladiolus* in this country. The spore-balls average 40-50 μ diam. The central fertile spores are dark brown, angularly globose, smooth, 4-6 μ diam., sterile peripheral cells numerous, pale.

Destroy infected corms, as cure is out of question.

ENTYLOMA (DE BARY)

Mycelium intercellular, not gelatinous, spores solitary, terminal or intercalary, germination as in *Tilletia*, often crowded, epispore thick, generally multistratose, hyaline or brownish, smooth or ornamented; promycelium filiform, sporidiola many, acrogenous, elongated, for the most part conjugating in pairs.

Conidia present in some species, forming white tufts on living leaves, etc. (= *Cylindrosporium*).

Entyloma crepidicola (Trot.). This fungus forms galls 4-5 mm. diam. on the fibrous rootlets and on the filiform rhizomes of *Crepis bulbosa* in Italy. It was first described by the author as *Urophlyctis crepidicola*. In a section of a gall, the spores are seen in dense black masses scattered in its substance, and resembling in habit the genus *Urophlyctis*.

Spores subglobose or ellipsoid, often angular from mutual pressure, deep chestnut-brown, smooth, 13-15 μ.

Trotter, A., *Ann. Mycol.*, 6, p. 19 (1908).
Trotter, A., *Marcellia*, 6, p. 26 (1907).

Entyloma Aschersonii, Wor. (= *E. Magnusii*, Wor.), forms tubercles up to 1 cm. diameter, on stems and roots of *Helichrysum* and *Gnaphalium* in Germany.

Spores globose or elliptical, sometimes irregular, brown, $15\text{-}22 \times 11\text{-}20\ \mu$, epispore multi-stratose, 4-7 μ thick.

GRAPHIOLA (POIT.)

Erumpent; peridium minute, black, forming a wall out of which arises a tuft of yellow hyphae which carry the spores up with them.

Confined to palms as host-plants.

Palm smut (*Graphiola phoenicis*, Poit.) is parasitic on the leaves of *Phoenix dactylifera*, *Chamaerops humilis*, and probably other species of palms, and often proves troublesome in conservatories. The fungus forms numerous minute black warts having a central depression, out of which arises a long yellow cluster of hyphae, looking like a miniature paint-brush. When the latter disappears, the hard, black wall persists.

Erumpent, wall hard, black externally, 1-2 mm. diam., spores pale yellow, 5-6 μ diam., carried up on a plume-like tuft of yellow hyphae 2-3 mm. long.

Sponging with a solution of permanganate of potash kills the spores.

BASIDIOMYCETES

Spores borne at the apex of a 1-celled basidium or specialised cell. Spores 1-celled.

GASTEROMYCETACEAE

This group is characterised by having the hymenium enclosed and completely concealed from view until the spores are mature. The puffballs (*Lycoperdon*), bird's-nest fungi (*Cyathus*), stinkhorns (*Ithyphallus*), and several subterranean fungi commonly mistaken for truffles, but distinguished by having the spores produced on basidia instead of in asci, are familiar examples. Perhaps there are fewer true parasites included in this group of fungi than in any other. The strong smell of the stinkhorns is for the purpose of attracting flies, who feed on the slimy substance on the hymenium in which the very minute spores are involved. By these means the spores are spread, those that pass through the body of a fly germinating readily.

ITHYPHALLUS

Receptacle bursting through the volva and becoming elongated, hollow, cellular, perforated at the apex, pileus reticulated, attached only to the apex of the receptacle which it covers like a loose thimble.

Vine root rot (*Ithyphallus impudicus*, Fischer) perhaps better known under the old name of *Phallus impudicus* (Grev.), is a very common fungus in this country, and readily recognised by its peculiar appearance, and its abominable smell at maturity. When young the fungus is buried in humus and spreads in all directions underground by means of snow-white, cord-like mycelium. According to Istvanffi, the mycelium of this fungus is very injurious to vines, entering the roots and stem near the ground-level and causing a

FIG. 106.—*Ithyphallus caninus.* Fungus about half nat. size.

kind of root-rot which eventually kills the vine. So far as I am aware there is no record of injury caused to cultivated plants in this country by this fungus, yet as in many other well-proved cases, a fungus, for some hitherto unknown reason, suddenly assumes the character of a destructive parasite. The 'Stinkhorn,' as *Ithyphallus* is called by country people, is often a great nuisance when it grows in hedgerows or under bushes in gardens, on account of its very offensive

FIG. 107.—*Ithyphallus caninus.* Hymenium of fungus partly covered with olive mucus, in which the very minute spores are embedded. Several flies are present feeding on the mucus. Nat. size.

smell. The fungus will be readily recognised by the aid of the accompanying illustration.

Mixing the soil with quicklime kills the mycelium.

Istvanffi, G., *Ann. de l'Inst. Ampélog. Roy. Hongrois*, 3 (1904).

AGARICACEAE

The members of this group come under the category of mushrooms and toadstools, in common parlance, and are

characterised by having the spores borne on gills or lamellae, usually placed below the cap or pileus.

ARMILLARIA

Pileus symmetrical, more or less fleshy; gills adnate or slightly decurrent; stem central, furnished with a ring; spores white, elliptical.

Beech agaric (*Armillaria mucida*, Schrad.) is a wound-parasite on the beech. At High Beech, Epping Forest, where this fungus is abundant on the beeches, its ravages are very evident in the way of wounds of a canker type, which eat deeply into the wood and may in course of time cause branches to be broken off by wind; beyond this it cannot be considered as a really destructive parasite. Its attacks are mainly confined to old trees, where it gains an entrance through broken branches, holes made by woodpeckers, etc. I broke off a healthy, fairly thick branch of a beech and placed spores of the fungus on the wounded part. At the end of the second season, after inoculation, the branch was killed for a considerable distance back, and the sporophores of the fungus were developed in abundance at the wounded portion of the branch.

Usually growing in clusters; pileus 1-4 in. across, subglobose, becoming almost plane, mucilaginous, whitish or grey; gills broad, white; stem 2-5 in. long, thickest at the base, white, often with dark squamules, ring thick, spores elliptical, $14\text{-}16 \times 8\text{-}9\ \mu$.

Tree root rot (*Armillaria mellea*, Vahl.) is undoubtedly the commonest and most generally distributed of any British fungus; it is also far from uncommon in many other countries. It is generally considered as a saprophyte, as it occurs in abundance around dead stumps, on logs, etc., and probably it may at times begin and pass through life as a pure saprophyte. It is highly probable that in most instances it has been more or less responsible for the death of the stump or log on which it is growing. In some instances the fungus appears to be growing directly out of the ground, but in such instances careful examination will show that it is attached to buried wood, roots, etc. Practically all kinds of trees, both broad-leaved and conifers, are attacked. The

root is first attacked, the mycelium gradually passing into the collar and lower portion of the trunk. The injury does not penetrate very deeply into the wood, but as the cambium and outer layers of sap-wood are gradually killed, the tree eventually dies. If the bark is removed from the collar or

FIG. 108.—*Armillaria mellea.* Group of plants about one quarter nat. size.

lower part of a tree that has been killed by the fungus, a sheet of pure white mycelium is seen investing the wood. The same appearance is observed in the root. In the case of conifers a considerable accumulation of resin is present at the collar; for this reason the disease was at one time known as resin-flux. The white mycelium between the wood and the bark often presents a fasciated or fan-like appearance and breaks up into strands, which either continue to extend between the

wood and the bark, or pass out through the bark and form rhizomorphs on its surface, which in the case of roots pass into the soil. After the death of the tree the shrinkage of the bark affords space for the further development of these

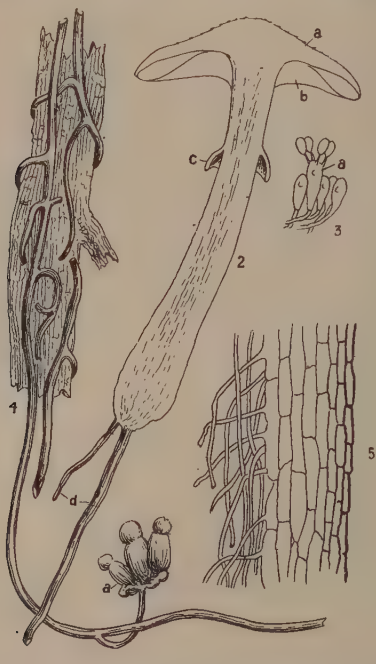

FIG. 109.—*Armillaria mellea.* 2, section of fungus, *a*, pileus; *b*, gills; *c*, ring; *d*, black, cordlike strands of mycelium; 3, basidium, *a*, accompanied by paraphyses; 4, portion of tree root with branching strands of mycelium surrounding it; *a*, a cluster of young fungi springing from the mycelium; 5, section from outside to centre of rhizomorph or black strand of mycelium. Figs. 3 and 5 mag.

strands, which become blackish in colour and form a complicated network. Such anastomosing black, cordlike strands, are very frequently seen on removing the loose bark from a dead trunk, and clearly indicate the cause of death. The dark-

coloured, cordlike rhizomorphs have a compact cortex consisting of short cells with thick, coloured walls; these change gradually into thin-walled hyphae towards the centre of the rhizomorph, which in reality is an elongated sclerotium.

FIG. 110.—*Agaricus melleus.* Base of stem of young Scots fir killed by the fungus. A portion of the stem is cut away to show the dense white layers of mycelium under the bark.

These rhizomorphs radiate in every direction in the soil, growing by the tip only, and eventually attack the roots of other trees, by dissolving the cortex and giving origin to a sheet of white mycelium between the wood and the bark as described above.

The sporophores usually grow in dense clusters, and surrounding objects become powdered with the falling spores, presenting the appearance of having been dredged with flour. Pileus 2-5 in. across, convex, then expanded, more or less olive-brown when young, changing to dingy yellow or honey colour when fully developed, and ornamented with minute darker scales; gills attached to the stem, dingy white; stem, 3-5 in. long, coloured like the pileus, more or less ragged below the large ring situated near its apex; spores white, elliptical, $9 \times 5\cdot6\ \mu$.

The fungus is edible and quite safe, but does not rank amongst the best of edible British fungi.

Where only comparatively few fruit or ornamental trees are attacked, Hartig's suggestion of isolating such trees by digging a narrow trench about a foot deep round each tree, prevents the underground rhizomorphs from spreading to neighbouring trees. This would be effective only if carried out during an early stage of the disease, before the rhizomorphs had spread far in the ground. Where open trenches are objectionable, tarred boards or sheets of galvanised iron could be sunk in the ground to a depth of six or eight inches. All sporophores of the fungus should be collected and destroyed before their spores are dispersed. The above methods are almost impracticable when dealing with extensive woods, etc.

Hartig, *Die Zersekzung. des Holzes*, p. 59.

Hartig and Somerville, *The Diseases of Trees* (Engl. ed.), p. 207.

Prillieux, *Malad. des Plantes Agric.*, 1, p. 377.

MARASMIUS (Fries.)

Tough, thin, dry, reviving when moistened, and not putrescent; stem cartilaginous or horny; gills tough, distant, often connected by veins, spores white.

Banana plant disease.—This disease is very prevalent in some of the West Indian islands, and is caused by a small agaric called *Marasmius semiustus* (Berk. and Curt.). It often occurs in immense numbers on the stem of the banana plant, and the mycelium infects the flower-stalk and the inflorescence as they grow up the centre of the leaf-sheaths forming the spurious stem. Numerous minute, whitish

sclerotia are produced in the tissues of the plant; these are more or less globose.

Cap white, becoming tinged rufous, eccentric, soon plane, with deep grooves, $\frac{1}{2}$-$\frac{3}{4}$ in. diam. Gills distant, connected by ridges; stem, $\frac{1}{2}$-$\frac{3}{4}$ in. long, forming a small pale sclerotium in the tissues of the host-plant.

The only effective remedy is the removal and burning of diseased plants. If these are allowed to remain and decay, the numerous sclerotia are liable to infect other plants.

Massee, *Text-Book of Plant Diseases*, p. 206 (1903).

Marasmius sacchari (Wakker) has been proved by experiments to be a true parasite on sugar-cane in Java.

Wakker and Went, *Zeikt. van het Sinkerriet op Java*, p. 194.

SCHIZOPHYLLUM (Fries.)

Pileus very thin, dry; gills dry, branched, edge split open longitudinally.

Schizophyllum commune (Fr.). Is said to be parasitic on the sugar-cane in the West Indies. It has also been recorded as doing injury to the horse-chestnut and mulberry in France.

This species is rare in England, but I once found it growing on the living trunk of *Alnus glutinosa*, near Scarborough.

Pileus very thin, fan-shaped, greyish-white, often lobed, downy, 1-2 in. broad; gills pale brown with a tinge of purple, split portion of gills recurved; spores dingy, $4\text{-}6 \times 2\text{-}3\ \mu$.

Guégen, *Bull. Soc. Myc. France*, 17, p. 238.

Prillieux and Delacroix, *Bull. du Ministère de l'Agric.*, No. 5, Sept. 1893.

PHOLIOTA (Fries.)

Pileus symmetrical, more or less fleshy; gills adnate, becoming rusty at maturity; stem central, with a distinct ring.

Slimy tree agaric (*Pholiota adiposa*, Fries.) is not uncommon as a saprophyte, and is also abundant as a wound-parasite on various broad-leaved trees, also on conifers.

The white wood of the fir becomes yellow or honey coloured, with scattered patches of light brown, and finally breaks up into irregular pieces under the influence of the mycelium.

Pileus 2-4 in. across, fleshy, yellow, with darker scales,

FIG. 111.—*Pholiota adiposa.* 1, cluster of fungi; *a*, pileus; *b*, stem; half nat. size. 2, section of pileus; *a*, *a*, lamellae or gills; *b*, *b*, veil. 3, spores, highly mag.

very glutinous; gills yellow, then rusty; stem yellow with rusty scales, ring near apex.

The following species of *Pholiota* are sometimes met with growing from wounds on living trees: *P. aurivella* (Batsch), *P. squarrosa* (Müll.), and *P. destruens* (Brond.).

HYPHOLOMA

Pileus fleshy, margin incurved when young; stem central, veil appendiculate, not forming a distinct ring; gills adnate or sinuate, spores purple-brown.

Raspberry root rot (*Hypholoma fasciculare*, Fries.), although one of the commonest and most generally distributed of British fungi, has not been proved to be parasitic in this country. Dr. M'Alpine, however, states that this species is very destructive to raspberries in Victoria, forming a dense white mycelium round the roots.

Growing in dense tufts. Taste bitter. Pileus 1-3 in. across, tawny, margin yellow; gills yellow, then greenish, stem yellow.

M'Alpine advises drainage and liming the soil, removal and burning of diseased plants. The addition of salt to the lime in the proportion of two of lime to one of salt is recommended.

PSILOCYBE (Fries).

Pileus smooth, margin at first incurved; gills and spores at length brownish or purplish; stem central, cartilaginous, hollow or stuffed, veil absent or rudimentary.

A cereal infesting agaric.—Dr. Yungner-Posen describes the occurrence of minute sclerotia on fading leaves of seedling rye and wheat. The sclerotia proved to be those of *Psilocybe Henningsii* (Yungner-Posen). The sclerotia are about the size of a clover seed, sometimes a little larger, yellow, then reddish-brown.

Pileus grey, then tinged brown, edge minutely striate, 10-18 mm. diam., gills broadly adnate, grey then blackish; stem slender, flexuous, grey, tinged brown, 2-3 cm. long, springing from a sclerotium; spores elliptic-fusoid or ovate, reddish-brown, $10\text{-}13 \times 6\text{-}7\ \mu$, smooth.

Yungner-Posen, *Zeit. Pflanzenkr.*, 16, p. 131 (1906).

Hemi-parasitic agarics.—Hennings points out that in addition to the list of agarics usually included as being more or less of a parasitic nature, many other species of gill-bearing fungi are constantly met with on the dead stumps of trees, sometimes on living trees, and suggests that

these under certain conditions may become true parasites. It is considered that the mycelium of many species may be parasitic in the living tree, but that, as a rule, sporophores are only produced after the tree is dead. The following are included by him in this category.

Lenzites sepiaria (Fr.). Occurs very frequently on old stumps of Scots fir, less frequently on living trunks of the same tree, and abundantly on the worked wood.

Lenzites abietina (Bull.) occurs abundantly on stumps of pines and silver fir.

Lenzites betulina (Fr.) is common on stumps of birch, oak, and beech; less frequently on living trunks.

Lenzites variegata (Fr.). On stumps of birch and oak, and on living trunks of beech, poplar, and *Prunus avium*.

Lentinus squamosus, Fr. (= *L. lepideus*, Fr.), especially on stumps of Scots fir.

Lentinus conchatus (Fr.). On trunks of poplar and silver birch.

Panus stypticus (Fr.). Abundantly on stumps; also on living trunks of alder, hazel, birch, and beech.

Paxillus panuoides (Fr.). On stumps of Scots fir.

Psathyrella disseminata (Fr.). On stumps of many broad-leaved trees, especially birch.

Psilocybe spadicea (Schaeff.). Very abundant in dense tufts on stumps and roots of various broad-leaved trees. Less frequently on living trunks of lime, elm, willow, maple, and beech.

Hypholoma appendiculatum (Bull.). Everywhere on stumps, and on roots of living trees; especially willows, poplars, beech, and lime. Probably parasitic on roots.

Hypholoma fasciculare (Huds.). Abundantly on stumps of both conifers and broad-leaved trees; also on living trunks of oak, poplar, elm, and Scots fir. Probably a true parasite at times.

Hypholoma lateritium (Schaeff.). Abundant in clusters on stumps of beech, birch, maple, horse-chestnut; also on living beech trunks.

Flammula alnicola (Fr.). On stumps; less frequently on living trunks of alder. According to Schröter it occurs on trunks of lime, elm, and willow, and is a root parasite.

Pholiota squarrosa (Müll.). Very frequently on trunks of various kinds of broad-leaved trees.

Pholiota aurivella (Batsch.). Less frequently than the

preceding on living trunks of birch, alder, willow, beech, apple. On *Ailanthus glandulosa* in the Berlin Botanic Garden.

Pholiota adiposa (Fr.). Not uncommon on living trunks of alder, birch, elm, willow, beech, oak, and apple.

Pholiota spectabilis (Fr.). On stumps and roots of alder and oak. Probably a root parasite.

Pholiota destruens (Brond.). A very destructive parasite on poplars; also attacks birch and willow.

Pholiota mutabilis (Schaeff.). Pre-eminently the stump fungus present on stumps of various trees, as beech, oak, birch, alder, willow, and maple; sometimes on living trunk and root of beech.

Pluteus cervinus (Schaeff.). On stumps of various broad-leaved and coniferous trees, especially Scots fir, where it sometimes occurs in abundance on the living trunk.

The white variety, *rigens*, occurred on birch, and growing out of wounds on an oak trunk.

Volvaria bombycina (Schaeff.). In Berlin Botanic Garden in a hollow trunk of *Acer dasycarpum*; also on trunk of *Populus canadensis*.

Pleurotus ostreatus (Jacq.). On living trunks of various kinds of broad-leaved trees.

Pleurotus salignus (Pers.), as also the previous species, on living trunks of various willows, birch, poplar, alder, and on stumps of *Robinia* and mulberry.

Pleurotus ulmarius (Bull.), especially on living elm trunks. Schröter says it also occurs on lime trunks.

Several other species of *Pleurotus* also occur on living plants, as *P. atrocoeruleus* (Fr.) on willows and mountain ash; *P. mitis* on Scots fir; *P. corticatus* (Fr.) on poplars; also growing from wounded places in trunks of *Ostrya virginiana* and *Sophora japonica*, in the Berlin Botanic Gardens.

Collybia velutipes (Curt.). On stumps of very many kinds of broad-leafed trees; also abundantly on living trunks of willows, birch, oak, alder, lime, beech, poplar, elm, horse-chestnut, etc. The willows in the Berlin Botanic Gardens are badly infested with this fungus.

Tricholoma rutilans (Schaeff.). On stumps and roots of Scots fir; also on living trunk of same tree. A root parasite.

Armillaria mucida (Schrad.). On living trunks and branches of beech.

The foregoing suggests the great probability that all the species enumerated are capable of acting as parasites, and of doing a great amount of injury, yet in no instance has this surmise been corroborated by scientific research. This awaits some one with time and facilities at command.

POLYPORACEAE

The most characteristic structural feature of the present family consists in the hymenium or spore-bearing surface being composed of tubes, the cavities of which are lined with basidia bearing the spores. In a typical genus like *Polyporus* these tubes are elongated, sometimes exceeding half an inch in length, and arranged closely side by side, resembling a number of closely packed drain-pipes standing on end. As would be expected, all genera are not equally typical, and in some instances the pores are quite shallow, and in others, as *Merulius*, the entire surface of the hymenium is covered with slightly raised anastomosing veins, which form shallow pits or depressions on the surface.

On the other hand such genera as *Daedalea*, which form a connecting-link between the Polyporaceae and Agaricaceae, show a decided tendency to form gill-like structures on the hymenium, in fact it is not unusual to meet with both gills and pores on different parts of the hymenium in *Daedalea*.

Many of the largest of fungi belong to the present family, as also some of the most durable, the perennial species of *Fomes* often being of a woody consistency. All the large bracket-shaped or hoof-shaped fungi, so common on trunks, are members of the present family.

The species are pre-eminently wound-parasites, although some few are true parasites. The majority attack trees, causing various kinds of wood decomposition, as heart-rot, root-rot, etc.

Many species, the properties of which have not been investigated, grow on living trunks, and will probably be shown to be parasites.

MERULIUS (Hall)

Hymenophore resupinate, subgelatinous, surface variously plicate, surrounded by white, radiating mycelium.

Distinguished by the subgelatinous consistency when moist.

Dry Rot (*Merulius lacrymans*, Fries.).—The cause of this mischief is almost unknown in a wild state, although as a destroyer of worked timber it occurs practically everywhere.

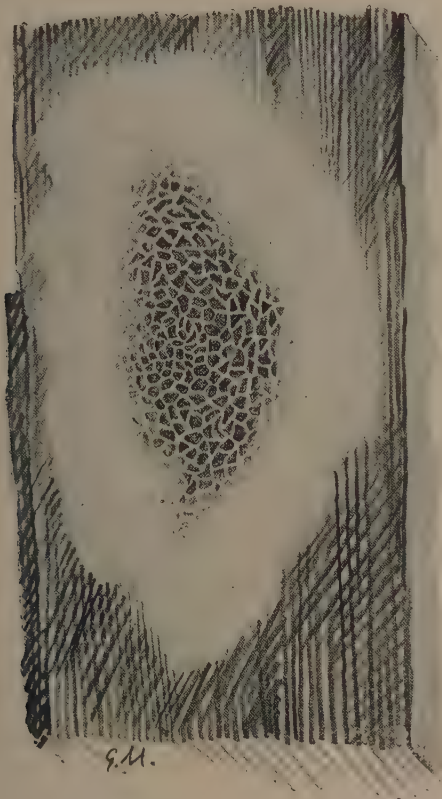

FIG. 112.—*Merulius lacrymans.* 'Dry-rot'; young specimen, nat. size.

The specific name '*lacrymans*,' or weeping, was given on account of the drops of water that frequently drip from the fungus, and which it has the power of absorbing from the atmosphere. This moisture enables the fungus to attack

originally dry-wood which, after it has been disorganised, becomes dry and rotten, hence the common name of 'dry-rot.' The fruiting portion of the fungus is a thickish, felt-like patch of variable size, from four to eight inches across, and is attached throughout by its under surface to the substance it is growing upon. The upper spore-bearing surface is covered with slightly raised ribs anastomosing to form an irregular network; it has been compared in general appearance to a piece of tripe. When the spores are ripe the hymenium is of a deep brown or snuff colour, and powdery. Spores elliptical, bright brown, 10-11–5·6 μ. The margin of the hymenium consists of white mycelium which in a vigorously growing specimen resembles cotton wool. This marginal portion keeps extending outwards and adding to the size of the hymenium. When the fungus becomes old the white mycelium changes to a dull grey colour. The entire fungus can be readily removed from its support, and presents the appearance of a thick sheet of felt or leather. Under certain conditions the entire hymenium remains sterile, and of a dirty grey colour.

When a dry-rot fungus has become well established, numerous strands and flat plates of mycelium, white at first, then greyish, spread out from every part of the white margin of the hymenium. These strands grow along walls or whatever kind of support happens to be forthcoming, being supplied with food and moisture from the parent plant. When wood is reached by any of these strands, a new headquarter is formed, and a new hymenium is produced, from which strands of mycelium again emanate and extend in every available direction until more wood is reached, when the process of forming a new centre of food supply is carried out. By these means, if dry-rot once gains admission to a house, it is possible for it to reach every part from basement to attic.

Infection of wood often takes place in the forest, when felled timber remains stored there for some time. The earliest evidence of infection is indicated by the presence of red stripes in the wood. If such timber is afterwards thoroughly seasoned and dried the mycelium of dry-rot in the red stripes is killed, but if the seasoning is only imperfectly carried out, as is usual at the present day, the fungus mycelium remains latent, and may begin active growth if the wood is placed in a damp, badly ventilated part of a

building, and more especially when the ends of joists are built into a wall in the basement of a house.

Another source of infection of new wood is due to the frequent presence of old infected beams and boards in timber-yards, from which spores are being constantly diffused, or by the spreading of mycelium from such old wood to the new stock stored in the same yard.

Broadly effused, usually resupinate, soft and rather moist, yellowish-brown in the centre, margin whitish. Spores rusty yellow, elliptical, $10\text{-}12 \times 5\text{-}6\ \mu$.

Dr. Carpenter's experience of dry-rot is as follows: 'I know a house into which the rot gained admittance, and which, during the four years we rented it, had the parlours twice wainscoted and a new flight of stairs, the dry-rot having rendered it unsafe to go from the ground floor to the bedrooms. Every precaution was taken to remove the decaying timbers when the new work was done; yet the dry-rot so rapidly gained strength that the house was ultimately pulled down.'

The idea of excluding dry-rot from a building, by hermetically closing all outer air from spaces between joists and flooring-boards, etc., is an entirely wrong principle, because as a rule the disease is already present in the wood when used. An attempt of this kind was made in the case of a mansion recently erected, and the result proved disastrous.

The ends of joists that are going to be built into a wall should first be thoroughly soaked with creosote, as should all wood showing red-stripe.

Creosote is much more effective than gas-tar, as the latter prevents the wood from drying, and thus actually favours the growth of the fungus, if present in the wood. The surface of flooring-boards coming into contact with 'deadening' material should first be brushed over with methylated spirit containing corrosive sublimate in solution—six ounces to one gallon. The spirit soon evaporates and leaves a coating of corrosive sublimate on the boards, which prevents the growth of the fungus.

A constant source of trouble arises from the use of 'pugging' or deadening material before it is thoroughly dry. Coarse sand is the best to use for the purpose. Coal-dust, cinders, or humus should not be used, as favouring the fungus, whose spores germinate in moisture having an alkaline reaction.

A thoroughly good system of ventilation in the basement of a building is of primary importance.

DAEDALEA (Pers.)

Substance corky or woody, pores on the under surface of the pileus, becoming elongated and irregularly wavy, dissepiments thick, corky, flexible when elongated.

Distinguished from *Trametes* and *Polyporus* by the long, irregularly contorted openings of the pores. A genus that connects the gill-like structure of the hymenium of *Agaricus* with the porous form of the hymenium in *Polyporus*.

Daedalea quercina (Pers.). This fungus has been observed growing on branch wounds of old oak-trees, and some people suspect that it is a parasite. It is certainly not uncommon on old trunks and stumps of oak in Britain.

Said to be very destructive to railway ties in the United States.

Every part pale wood-colour. Pileus corky, rugulose and uneven, in large specimens often much lobed, as if composed of several confluent pilei, 4-10 in. across. Pores at first roundish, becoming elongated, gill-like, and irregular, dissepiments thick and elastic.

Perennial. Pileus often with concentric, depressed zones.

TRAMETES (Fries.)

More or less bracket-shaped, pileus hard, tubes originating at various depths in the flesh of the pileus, and in this respect differing from other members of the Polyporaceae.

Some of the species have a pleasant spicy odour.

Pine Trametes (*Trametes pini*, Fries.).—This fungus is rare in Britain, but according to Hartig it is very destructive in the pine woods of North Germany.

The fungus is a wound-parasite, and rarely attacks trees under fifty years of age.

Attached by a broad base, more or less triangular in section, pileus rusty brown, then blackish, concentrically grooved, rough, margin strigose, 3-4 in. broad, flesh rusty, very hard; tubes indistinctly stratified, bright rusty, pores irregular in form. Hartig says a sporophore may live for fifty years.

As the mycelium always spreads very extensively before sporophores appear, any attempt at cure is hopeless, and the only thing to do is to cut down and remove diseased trees.

Trametes suaveolens (Fries.). Occurs on willows, but does comparatively no injury.

Smell resembling aniseed. Pileus whitish, downy, 3-6 in. across, flesh white, corky; tubes ½ in. or more in length, pores large, irregularly rounded.

PORIA (Pers.)

Entirely resupinate, often forming large patches, covered with the pores or hymenium, flesh thin, often almost absent.

The numerous species are mostly saprophytic on fallen wood or branches, and many are in all probability only reduced conditions of *Fomes* or *Polyporus*.

Poria vaporaria (Fr.) is probably the most abundant and most generally distributed of polyporus fungi. As a saprophyte it is present on practically every other fallen branch throughout the kingdom. In addition it sometimes assumes a parasitic life, entering through wounds caused by the nibbling of various animals, etc. Conifers are most frequently attacked, and the wood becomes reddish-brown, cracked, and dry. The mycelium forms sheets in cracks of the wood, or between the wood and the bark under the form of branched, woolly strands, much resembling those of the dry-rot fungus (*Merulius lacrymans*) from which they can be readily distinguished by remaining pure white, instead of changing soon to a dull grey colour. In addition the fungus often does considerable injury to worked timber, more especially when exposed to damp as in greenhouses, etc., and in such positions may at first be mistaken for dry-rot, but can be distinguished by the colour of the mycelium as already stated, and by the distinct white pores when in a fruiting condition.

Broadly effused, thin, inseparable from the matrix; pores large, angular or wavy, white, then yellowish.

When worked timber is attacked the treatment recommended for dry-rot should be followed.

Poria subacida (Peck) is stated by Schrenk as probably being one of the species causing injury to living conifers; it is certainly an active destroyer of dead timber. This species is recognised in the forest by the copious formation of masses

of yellow mycelium, which occur round the root, and appearing between chinks in the bark. It is suspected that the mycelium migrates from one tree to another underground, as in *P. schweinitzii.*

Effused, separable, tough, pores minute, often oblique, whitish, then becoming tinged yellow.

Schrenk, E. von, *U.S. Dept. Agric.*, *Div. Veg. Phys. and Pathol.*, Bull. No. 25 (1900).

Poria Laestadii (Fr. and Berk.). I once found this rare

FIG. 113.—*Poria vaporaria.* 1, portion of fungus, nat. size; 2, section of same.

fungus growing in abundance on deal boards in a hothouse in Kew Gardens. It proved most destructive, causing the wood to break up into cubes and gradually crumble to pieces.

Very thin and easily separable from the matrix, tuberculose

here and there; pores shallow, circular or irregular, bright citron-yellow, minute; spores $5 \times 2{\cdot}5\ \mu$.

FOMES (Fries.)

Perennial. Pileus thick, bracket or hoof-shaped, hard and woody, often with concentrical ridges, not colour-zoned; tubes stratified, the external stratum of tubes alone producing spores.

Conidial forms are known in some species.

Amongst the largest and most persistent of fungi, many species are destructive parasites on trees.

The tinder fungus (*Fomes fomentarius*, Fries.) is one of our most destructive wound-parasites, attacking many kinds of trees, as beech, elm, and various fruit-trees. It does not attack conifers. The large, hard, bracket-like, fruiting bodies only appear on the surface of the trunk of the tree after the mycelium has been present in the wood for some considerable time. The effect produced by the mycelium on the wood has been termed white-rot by Hartig, on account of the heart-wood which is first attacked assuming a white colour, and becoming broken up into cubes by the action of the mycelium. As decay proceeds, thin, skin-like layers of mycelium, resembling kid leather, are formed in the cracks in the wood; these sheets grow outwards towards the bark, and at length give origin to the external fruiting bodies. Tubeuf says that the marked depression or groove in the trunk above and below the fruiting bodies is due to the mycelium of the fungus having destroyed the cambium, and thus prevented the further formation of wood at these parts. Hoof-shaped, thick, 4-8 in. across, 4-6 in. thick, concentrically grooved, brown, margin whitish, especially when young. Flesh thick, rather soft, brown. Tubes long, stratose, rusty, pores white, then brown; spores brown, $6 \times 3{\cdot}5\text{-}4\ \mu$.

The section of entire fungus is more or less triangular. The surface of the pileus is covered with a snuff-coloured powder—a conidial form of reproduction—which distinguishes this from allied species. For further distinctions from other species, see remarks under *P. igniarius* (Fr.).

At one time the soft brown, fleshy portion of this fungus was used for tinder. At a later period the flesh, after being cut into sections and specially prepared, furnished large sheets

of a brown, felt-like substance, used in the production of a great variety of articles, as purses, chest-preservers, slippers, bags, etc. A good collection of articles made from this substance are on view in No. 2 Museum, Royal Botanic Gardens, Kew. Tubeuf states that at one time the sporophores of *Fomes fomentarius*, the tinder fungus, were so numerous and large that for their collection for manufacture of caps, gloves, tinder, etc., a sum of one hundred gulden

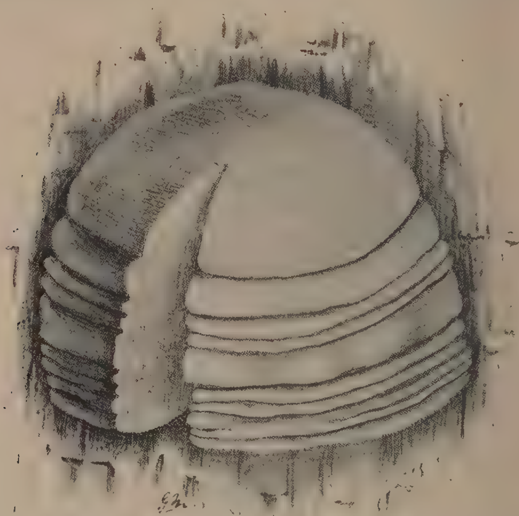

FIG. 114.—*Fomes fomentarius.* Fungus with a portion cut out to show stratified pores, reduced.

(£8, 10s. 0d.) was paid annually for the material obtained from Bischoffsrent forest in Bavaria. Ten years ago the same brought in a revenue of twelve shillings, to-day it is free, owing to our advance in knowledge as to the injurious effect of fungus parasites, and the adoption of means for the prevention of the same.

Unfortunately preventive measures against this, as well as other of the larger wound-fungi, are practically confined to protecting injured surfaces by means of gas-tar. Fruiting

bodies of the fungus should be removed and burned, and the parts exposed coated as mentioned above. Too frequently old fallen trunks, bearing numerous sporophores or fruiting bodies of the fungus, are left lying about. All such should be removed at once, to prevent infection of neighbouring trees by spores.

The fact that the fungus grows on dead wood is often used as an argument that the fungus is harmless, and only grows on dead or dying trees. This, however, is a mistake. In common with all wound-fungi, the present can live perfectly well as a saprophyte, but when occasion offers, it enters into living tissues through a wound, and continues to grow as a true parasite.

Hartig and Somerville, *Diseases of Trees*, p. 206 (1894).
Tubeuf, *Diseases of Plants*.

False tinder fungus (*Fomes igniarius*, Fries.) is a wound-parasite most frequent on the oak, but also attacks various fruit-trees, beech, willow, alder, etc. Hartig states that it is also parasitic on the larch. The spores germinate on a wound, and the mycelium spreads quickly in the wood, which changes to a brown colour at first, and by degrees becomes yellowish-white when disintegration sets in. The tannin dissolved in the cell-sap is absorbed by the mycelium, and after undergoing metabolic changes serves as food for the fungus. The mycelium, after extending for some time in the wood, spreads into the bark and produces the large, hard, concentrically grooved fruiting bodies on the surface of the trunk.

Bursting through the bark as a roundish knob, it gradually assumes a hoof-like form, surface brown or almost black when old, concentrically grooved, cuticle very hard, 3-6 in. broad, 2 in. thick; flesh rusty, zoned; tubes 1-2 in. long, stratose; spores subglobose, hyaline, 6-7 μ diam.

Allied to *P. fomentarius*, but a thinner plant, cuticle and flesh hard, tubes filled with white mycelium when old.

The hard flesh renders this fungus unsuitable for making tinder, felt, etc.

The preventive measures given under *P. fomentarius* are equally applicable to this species.

Conifer root rot (*Fomes annosus*, Fries., = *Trametes radiciperda*, Hartig) is certainly the most destructive of the large

fungi attacking conifers; it occurs on *Pinus*, *Abies*, *Picea*, *Juniperus*, and *Larix*. In this country the larch undoubtedly suffers most. This fungus differs from the majority of the polypores in not being a wound-parasite, but a true parasite, the germinating spores entering into the living tissues of the root, where a delicate white sheet of mycelium is formed

FIG. 115.—*Fomes annosus*. 1, portion of fungus; 2, section of same, showing stratified tubes in three layers; 3, portion of hymenium, showing tubes and their openings, slightly mag.

between the bark and the wood. Soon after the mycelium has extended in the wood the latter changes to a lilac or violet colour, and afterwards to a yellowish-brown, and becomes light and spongy. The mycelium simultaneously extends up the trunk and towards the tips of the roots. When the roots have become thoroughly infested with mycelium, flattened, biscuit-like, pure white fruiting bodies or sporophores are produced on the surface of the underground

roots. At a later stage, when the tree is dead, or nearly so, normal sporophores, 2 to 6 inches across, are produced on any portions of roots projecting above ground, and at the base of the trunk. These sporophores continue to be produced for many years after the tree is dead, and may commonly be found on old stumps of larch.

In this disease death is due to the complete destruction of the root by the fungus. Young trees suffer most, but quite old trees are also killed.

Irregular in form, often horizontal and imbricated, 3-6 in. across. Pileus convex, becoming plane, tuberculately zoned, and coarsely, radially rugulose, brown, thickish, margin white. Flesh whitish, tubes white, about a quarter of an inch long, stratose, pores white, spores $6 \times 4\ \mu$ hyaline.

Flattish, biscuit-like, white sporophores are often produced on the roots of living conifers underground.

Brefeld has described a conidial form of this species, which consists of a white mould, bearing numerous simple or branched conidiophores, each branch terminating in a swollen, subglobose bead, bearing numerous elliptical conidia on slender sterigina-like bodies. Brefeld has changed the name of *Fomes annosus* to that of *Heterobasidion annosum*, and gives *Trametes radiciperda* (Hartig) as a synonym.

Hartig has shown that the disease may be communicated in a subterranean manner by means of mycelium, as where a diseased root comes in contact with a sound root of an adjoining tree. The mycelium also spreads underground from diseased to healthy trees after the manner of the rhizomorphic mycelium of *Armillaria mellea*. To prevent this underground extension of mycelium, it is recommended that a narrow, deep trench be made round diseased trees at a sufficient distance from the tree to include all the roots. The mycelium, which does not travel deep down in the soil, cannot pass the open trench. In a nursery, or plantation of young trees, diseased specimens should be promptly removed. All sporophores of the fungus, whether on living trees or dead stumps, should be collected and burned, otherwise the spores are a constant source of danger, and are scattered by wind, mice, etc.

Brefeld, *Unters. aus dem Gessamtg. der Mykol.*, 8.
Hartig, *Zersetzungsch. des Holzes*, p. 14.
Hartig and Somerville, *Diseases of Trees*, p. 186 (1894).

Gooseberry fungus (*Fomes ribis*, Fries.) is a wound-parasite not uncommon on the stems of gooseberry and currant bushes. Usually numerous pilei grow one above another up the stem, and eventually kill the bush.

Pilei growing horizontally, imbricated, flattened, rigid, thin, margin acute, velvety, rusty, then umber; flesh thin, tawny: pores minute, tubes about one line long.

Distinguished by the imbricated mode of growth, 2-4 in. across. Often tawny-yellow or rich tawny-brown, velvety. Substance soft, indistinctly zoned.

As the fungus only attacks old bushes, the best remedy is to replace by young ones. Burn the old infested ones.

Root rot of betel-nut palm—Much loss is experienced in many tracts of Sylhet, in India, from a root rot of *Areca catechu*. The earliest symptom is a dropping of the nuts, and nearly the whole of the produce of a palm may be lost in this way, during the early stage of the disease. Soon afterwards the swollen green part at the top of the stem, below the leafy head, diminishes in size, and quite the most striking symptom is the change from the graceful, curved swelling of the coverings of the terminal bud, to an almost straight-sided cone at the top of the tree. Withering of the leaves follows, beginning from the outside, and eventually the whole head dries up and falls off. The true source of injury resides in the root, which rots and decays, due to the presence of the mycelium of a fungus. The species was not determined, but the presence of 'clamp-connections' in the mycelium suggested a member of the Basidiomycetes. *Fomes lucidus* was often found at the base of the stem of a dead tree, and may eventually prove to be the source of mischief.

A trench two feet deep and a foot broad should be dug round the diseased patches of trees, sufficiently far away so as to include all diseased roots within the area. The soil dug out should be thrown inside the infected area. Trees inside the trench should be dug up and burned on the spot, and the land allowed to remain fallow for over a year.

Butler, *Agric. Journ. of India*, i. p. 302 (1906).

Root disease of Hevea brasiliensis.—A root rot of this tree when cultivated, has been announced from Singapore and Ceylon. The fungus concerned is *Fomes semitostus* (Berk.).

The fruit of the fungus is not formed until the tree has been dead for some considerable time.

Perennial, overlapping, dimidiate, 4-6 in. across, reddish-brown, margin thickened, yellowish, marked with concentric, darker zones, slightly sulcate and radially striate, silky; hymenium orange, then brownish, pores minute. Flesh whitish, zoned.

Infection by mycelium in the ground which extends from old stumps on which the fungus is often abundant. Such stumps should be removed.

Petch, *Roy. Bot. Gard., Ceylon*, 3, Circular No. 17 (1906).
Ridley, *Agr. Bull. Straits Sett.*, 3, p. 174.

Fomes Hartigii (Allesch.). This fungus is very closely allied to *Fomes igniarius*; however, it is parasitic on conifers and not on broad-leaved trees. It was described by Hartig under the name of *Polyporus fulvus*. It attacks more especially the silver fir, entering through wounds made by *Peridermium elatinum*, and causes a white rot of the wood. It has also occurred on spruce. The mycelium penetrates both sap-wood and heart-wood, and spreads at a great pace in the bark, and produces sporophores at various points. Wood when first attacked by the mycelium becomes pale yellow, the injured area being bounded by a dark brown line. The mycelium is brown or yellowish-brown.

The sporophore is hard, woody, persistent, subglobose, or forming irregular nodules, with the hymenium running down the tree for some distance. Pileus yellowish-brown, covered with short, harsh hairs, becoming greyish, smooth, and more or less concentrically grooved; hymenium greyish-brown or cinnamon, pores rounded, very minute, and not very pronounced. Spores hyaline. Flesh of pileus fawn-colour.

Fomes fulvus (Fries.) occurs on trunks of poplar and other trees; it is not common in this country.

Very hard, convex both above and below, attacked by a broad base, triangular in section; pileus even, downy when young, tawny, then greyish, flesh rusty; tubes short, not distinctly stratose, pores minute, cinnamon, with a greyish-yellow bloom.

POLYPORUS (Micheli)

Annual. Pileus fleshy, rather soft, not grooved nor colour-zoned, flesh composed of fibres, often radiating. Pores consisting of a single layer (not stratose).

Differs from *Fomes* in the soft consistency, pores not stratose, and in being annuals; from *Polystictus* in not having the pileus velvety and colour-zoned, and in the thicker flesh; from *Poria* in not being entirely resupinate.

Heart-wood rot.—This is caused by *Polyporus hispidus* (Fries.), a wound-parasite, which is very injurious to fruit-trees,

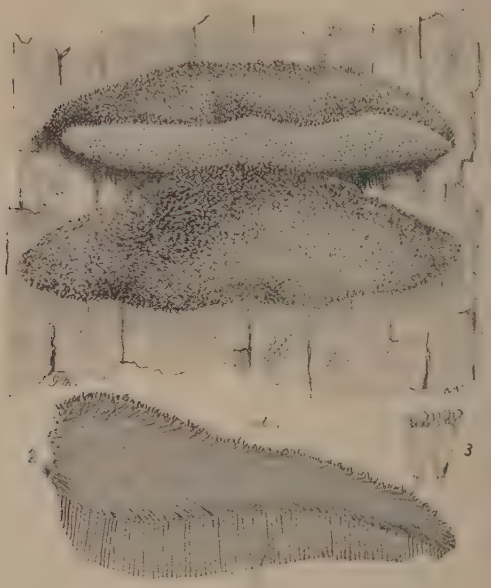

FIG. 116.—*Polyporus hispidus*. Fungus and section much reduced. Two basidia bearing spores, highly mag.

apple, pear, plum, etc.; it also attacks other trees, more especially the ash. Prillieux says that it is not uncommon on mulberry trunks in the Cevennes. This is one of the polypores that destroys the heart-wood, and begins its work in the wood near to the pith. From this point the disintegration of the trunk extends outwards towards the sap-wood. The decomposed wood a whitish colour tinged with rose, and is very friable, and the trunk eventually becomes hollow. A

narrow dark brown zone indicates the outward progress of the mycelium, and outside this band appears to be healthy, but a careful microscopic examination of the apparently sound wood reveals the presence of delicate strands of mycelium, which gradually extends towards the surface of the trunk; the brown zone in like manner is constantly advancing.

Often imbricated; pileus bracket-shaped, more or less semicircular, attached by a broad base, rather flat and not hoof-shaped, pileus rusty-brown, coarsely hispid, flesh spongy-fibrous, rusty; tubes $\frac{1}{2}$ to 1 in. long, yellowish-green, then brownish, pores minute, spores elliptic, orange-brown, $10 \times 7\ \mu$.

Pileus 4 in. to a foot across. Often very dark when old. When actively growing the tubes exude water which drips, carrying the spores along with it in considerable quantities. Every part of the fungus yields a deep yellow colouring matter—fungus gamboge, when soaked in spirit or in an alkaline solution.

Preventive measures, the same as given under allied species.

Prillieux, Ed., *Maladies des Plantes Agricoles*, 1, p. 352 (1895).

Birch polyporus (*Polyporus betulinus*, Fries.) is exceedingly abundant on birch-trees in this country, and when a considerable number of sporophores are present on a trunk the effect is certainly very artistic; to appreciate this to the fullest extent a visit should be paid to the old birch woods forming part of Sherwood Forest. The fungus is a wound-parasite, the mycelium produces a brown discoloration of the wood, which when decayed is permeated by snow-white strands of mycelium that extend outwards through the bark, and give origin to sporophores on the surface of the trunk. When a tree is once infected the mycelium continues to extend in the wood, and produces sporophores at different points each season.

Pileus corky, elastic, light, strongly hoof-shaped, 3-8 in. across, very fleshy, somewhat umbonate behind, attached by a narrowed portion, which sometimes is prolonged into a very short stem, whitish grey or brownish, smooth, margin incurved; flesh very thick, white; tubes short, spores minute, whitish.

Smell acid; epidermis thin, often cracking and peeling off in flakes. Whole plant very light.

When the object is to grow healthy trees for whatever purpose, all diseased trees should be cut down and burned at once, as when the mycelium has once gained an entrance it extends in the trunk from year to year.

Polyporus dryadeus (Fries.). This is our largest species of Polyporus, and is not infrequently met with on oak trunks; the largest specimens usually occur near the ground-line, but it also springs from points where branches have died or been

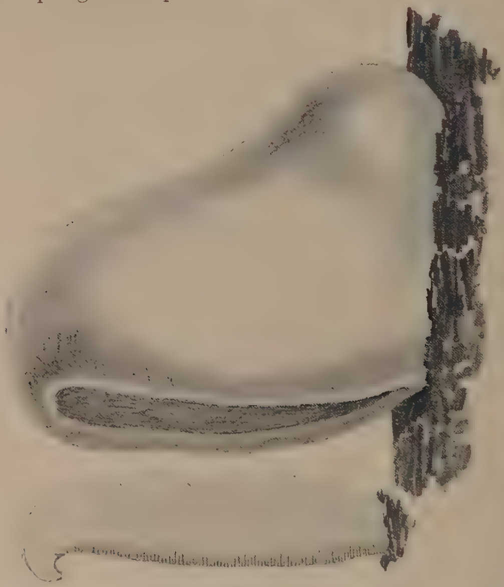

FIG. 117. –*Polyporus betulinus*. Fungus and section of same, reduced.

broken off. According to Hartig, during the decomposition of the wood by the mycelium, oblong yellowish or whitish blotches appear in the otherwise sound heart-wood. The cell-walls of these white blotches have been converted into cellulose, and have become isolated by the solution of the middle lamella. These patches are gradually dissolved, and holes surrounded by hard wood are formed.

Sporophore bracket-shaped or hoof-shaped, 7-12 in. across, attached by a broad base, becoming corky in substance,

pileus soft, rugged, becoming smooth, rusty, then dingy brown, margin often exuding drops of water, which leave depression when they dry up; flesh rusty, fibrous, somewhat zoned; tubes 1-2 in. long, thin, soft, rusty, pores small, round. Spores colourless, elliptical, $5 \times 3\ \mu$.

Often imbricated, smell somewhat acid, annual but persisting through the winter.

Polyporus salignus (Fries.). This species is often met with on decaying willows, but its connection with the death of the tree has not been determined.

Tufted or imbricated. Pilei 2-4 in. across, rather thick, white, slightly downy, grooved near the thick, more or less lobed margin; tubes elongated, pores tortuous, white. Inodorous.

Polyporus borealis (Fries.). This fungus is rare in this country, but Hartig says that it is the most frequent cause of decomposition of the spruce in the Bavarian Alps and in the spruce woods near Munich. Infection takes place above ground. The colour of the wood is but slightly changed during decomposition, it becomes brownish-yellow, and a series of horizontally arranged holes, filled with white mycelium, appear in vertical rows in the spring wood. Hartig was not able to determine why these holes are only formed at definite distances from each other.

Sporophore bracket-shaped, usually imbricated, 2-3 in. across, attached by a broad base, or narrowed behind into a short more or less distinct stem, pileus whitish, often more or less radially wrinkled, rather hairy; tubes 2-3 lines long, pores unequal, wavy, dissepiments torn; spores colourless, subglobose, 4 μ diam.

Inodorous when fresh, with a slight anise odour when dry. Usually imbricated, the pilei growing into each other. Often also met with on dead stumps of pine-trees.

Polyporus spumeus (Fries.). On both living and dead trunks of various kinds of trees.

Whitish, 2-4 in. across, fleshy, spongy, pulvinate, gibbous, rugose and hispid, margin incurved, base stem-like, flesh-zoned towards the margin; tubes short, pores minute, rounded.

The fungus oozes out of the bark in a very soft mass, which hardens in a day.

Polyporus destructor (Fries.). This fungus often occurs on worked wood, more especially in damp places. The wood is softened and destroyed in a similar manner as when attacked by dry rot.

Forming patches 3-6 in. long, effused or partly reflexed, fragile, rugose, brownish-white, rather fleshy, watery-zoned; tubes about $\frac{1}{2}$ in. long, pores white, roundish, the dissepiments or walls of the tubes becoming torn into teeth at the margin. Tubes forming nearly the whole of the fungus.

Polyporus giganteus (Fries.). This large fungus grows abundantly around old stumps, and also around the base of trees not yet dead, and in all probability is a parasite, although definite information on this point is not forthcoming. For some years a very beautiful, large beech-tree, growing in Kew Gardens, showed signs of being in some manner unhealthy. Suddenly one season, and for the first time, the ground under the tree was thickly studded with very large tufts of *P. giganteus*. The following season the tree died. When it was cut down, a thick felt of white mycelium was found between the bark and the wood of the lower part of the trunk; the wood was also permeated with mycelium, which formed white radial lines following the medullary rays. The main branches of the root were also saturated with mycelium, and in many instances the connection between tufts of the fungus and the root could be distinctly traced.

Tufts 2-3 feet across, formed of numerous overlapping pilei or flaps, which are broad, flaccid, and tough, distinctly fibrous when torn, often lobed, dingy greyish-brown, rather rough, all springing from a common, stem-like, tuberous base. Tubes short, pores minute, whitish, becoming dark coloured when bruised, a character that at once distinguishes this from allied species.

Polyporus sulphureus (Fries.). This fungus is a wound-parasite on many different kinds of trees, as oak, alder, willow, poplar, false acacia or *Robinia*, larch, and different fruit-trees. I once saw a magnificent specimen growing on the trunk of an old yew in Yorkshire. After the mycelium has gained an entrance the heart-wood is first disintegrated; during decay the wood changes to a reddish-brown colour and becomes much cracked, the cracks being filled with sheets of mycelium; the mycelium also fills up the vessels of the wood.

P. sulphureus is perhaps the most beautiful of our polypores, both as regards form and colour, but the smell is strong and decidedly unpleasant.

Tufted or imbricated, forming masses 9 in. to 3 feet across,

and weighing many pounds. Pilei wavy, margin often lobed, almost glabrous, yellow, or more or less suffused with red; flesh thick, yellow, then whitish, of a cheese-like consistency, not becoming hard when dry. Tubes up to $\frac{1}{2}$ in. long, pores

FIG. 118.—*Polyporus sulphureus.* 1, fungus, reduced; 2, section of same; 3, basidium bearing four spores, highly mag.

minute, primrose-yellow, spores elliptical, minutely warted, 7-8 $\times$ 4-5 μ.

Globose conidia are formed in special receptacles of the pileus, and also on the mycelium growing in the wood. A second conidial condition at one time considered as an

independent fungus and called *Ptychogaster aurantiacus.* These structures resemble in general appearance young spore-producing plants, and bear conidia in receptacles in the flesh, but do not form tubes bearing true spores.

FIG. 119.—*Polyporus sulfureus.* Block of white spruce wood showing injury caused by this fungus. (After Schrenk.)

Polyporus squamosus (Fries.). This very common fungus occurs abundantly on dead trunks and stumps of many kinds of trees exclusive of conifers, and is also equally common on old decaying trees, which it probably has in some measure been instrumental in destroying, but so far there is no reliable evidence to this effect.

Usually imbricated or several pilei from one point. Pilei on a more or less lateral stem, fan-shaped or nearly circular, fleshy behind, and becoming thin towards the margin, dingy

yellowish-white with darker adpressed scales, tubes short, pores large, irregular in form, whitish, stem short, base black, pores running down the stem.

Substance rather soft. A large fungus, pilei 4-8 in. across, sometimes much larger. Greville describes one which measured 7 ft. 5 in. in circumference, and weighed after having been cut four days, 34 lb. It was only four weeks in attaining the above size, gaining thus an acquisition of weight of above 1 lb. 3 oz. in the day.

FIG. 120.—*Polyporus squamosus.* Parasitic on trunk of sycamore, much reduced.

Red spruce disease (*Polyporus Schweinitzii*, Fr.) is a rare fungus in England, specimens of *P. hispidus* (Fr.) having an indication of a more or less central stem being usually mistaken for it. In the United States, however, according to Schrenk, it is one of the most destructive species of *Polyporus*, and is very common throughout the northern forests on the spruce and fir. The red spruce, *Picea rubens* (Sarg.), is said to be attacked in a wholesale manner. The fungus attacks both old and young trees, entering through the root and growing up the trunk, for sometimes 40 and 50 feet. There

is no evidence that trees are infected above ground. When the wood is infested with mycelium it turns yellow and becomes brittle, and afterwards cracks due to shrinkage of the wood. The cracking of the wood is said by Hartig to be due to spiral cracks forming in the walls of the tracheids, due to shrinkage of the substance of the wall. The mycelium does not form white branching strands, but sometimes covers the walls of the fissures with a white chalk-like coating. The smell of the decayed wood is very strong, and somewhat resembles turpentine without being identical.

This parasite appears to confine its attention to conifers. In Europe it has been recorded as parasitic upon the Scots fir, the Weymouth pine, and the larch. In the United States it attacks the white and red spruces, balsam fir, arbor vitae, and the white pine (*Pinus strobus*).

Sporophore dark rusty brown, coarsely tomentose or hispid, flesh thick, soft and fibrous, bright brown, tubes about 1 cm. long, pores large, irregular, greenish-yellow, spores pale yellow, $7\text{-}8 \times 4\ \mu$. Sometimes with a short, stout, central stem; when growing on a trunk often sessile and imbricated, 6-9 in. across. Schrenk says the hymenium is rose coloured when fresh, turning dark red very quickly when bruised. Are the European and United States fungi identical?

Von Schrenk, who has studied this species carefully in the United States, considers that it spreads through the soil, and only attacks a tree through the root system. He observed that wherever one tree is affected, others similarly diseased will usually be found close by. When infection occurs in the root on one side of a tree only the heart wood of that branch of the root will be destroyed, and the wood of the trunk nearest that particular branch of the root becomes affected.

Badly diseased trees should be felled, as when the trunk is once infected the mycelium continues to ascend higher and higher, and destroys wood that might be utilised if cut down earlier. The fruiting bodies of the fungus should be collected and burned or buried. The trenching method, if practicable, would check the spread of the mycelium in the ground from extending from diseased to adjoining healthy trees.

Hartig, *Zersetzunger*, p. 45 (there called *Polyporus mollis*).

Hartig and Somerville, *Diseases of Trees* (Engl. ed.), p. 198 (1894).

Schrenk, H. von, *U.S. Dept. Agr.*, *Div. Vet. Phys. and Path.*, *Bull.* No. 25 (1900).

Polyporus adustus (Fr.) is suspected of parasitic tendencies, but no definite proof is forthcoming. On the other hand, Dr. von Schrenk has shown that this fungus causes serious injury to logs of the red gum (*Liquidambar styraciflua*) in the United States. The injury he terms 'sap-rot,' on account of the sap-wood being attacked and destroyed. After logs have been sawn to the proper length and left lying on the ground for six months, the sap-wood at the cut ends is often covered with a dense growth of the fungus, the mycelium of which penetrates from six inches to two feet. The infected wood is bleached. At first there is no material disintegration of the wood, but as the fungus advances the wood becomes more or less pulpy and soft. When green, red gum has such a large quantity of water in its trunk that it sinks in water, hence the logs have to remain piled on the banks of streams for six months or even more, until they are light enough to be rafted to the saw-mills. It is during this period that the injury takes place, and when such diseased logs are sawn into boards it is found that one or two feet at each end of a board is worthless.

Sap-rot may be almost entirely prevented by coating the ends immediately the logs are cut with hot coal-tar creosote.

Schrenk, H. von, *U.S., Dept. Agric., Bureau of Plant Industry, Bull.* No. 114 (1907).

FISTULINA (Bull.)

Pileus soft and fleshy, flesh coloured and streaked, hymenium on the under surface, consisting first of warts which gradually develop into tubes which remain distinct from each other. Tubes at first closed, opening at length and having a fringed margin.

Conidia are produced in cavities of the old pileus.

Distinguished from the soft, fleshy kinds of *Polyporus* by the tubes of the hymenium remaining free from each other.

Beef-steak fungus (*Fistulina hepatica*, Fries.).—Hartig considers this to be a wound-parasite, and certainly it is very common on old living oaks in this country, less frequently on hornbeam and beech. It produces a deep red-brown decomposition in oak wood.

Pileus roundish, dimidiate or tongue-shaped, either

attached by a broad base, or narrowed behind and substipitate, dark blood-red, fleshy and soft, flesh streaked, tubes short, closed at first, pallid, then reddish, spores elliptical, $5\text{-}6 \times 3\text{-}4\ \mu$. Conidia $6\text{-}10 \times 5\ \mu$ are produced in the flesh of the pileus.

Popularly known as the beef-steak fungus, as a section of the pileus is red and streaked like raw beef. The plant when growing resembles large overlapping flaps of liver in colour, hence the specific name. Large, 4-12 in. across. One mass weighed just over forty pounds. Edible, but, like beef, is better for hanging for a couple of days before cooking.

HYDNACEAE

Sporophore pileate and stipitate, dimidiate, hymenium borne on crowded, awl-shaped spines.

HYDNUM (L.)

Hymenium inferior in pileate species, superior in resupinate forms, hymenium borne on spines that remain free from each other at the base.

Apple-tree Hydnum (*Hydnum scheidermayeri*, Heufler) is stated by Thümen to be a destructive parasite, attacking more especially apple-trees. The fungus is rare in this country. I have only found one specimen, which was growing in the hollow trunk of a crab-tree in the New Forest. It is a wound-parasite, and forms a dense mass of mycelium under the bark, often by this means completely ringing the tree; in other instances the wood is completely destroyed and cavities are formed. In the case of the crab-tree mentioned above, the hollow appeared as if it had been formed by the fungus. The dead wood was thoroughly disorganised and readily crumbled to powder when rubbed between the fingers. Wood that contains mycelium becomes yellowish-green in colour. The sporophores of the fungus either burst through the dead bark or grow in the hollow produced by the fungus, and are recognised among species of *Hydnum* by the spicy smell of aniseed exhaled on being broken.

Sporophore yellow, becoming tinged pinkish or brown; flesh yellow; fleshy, broadly effused, producing knobs or

tubercles here and there, bearing long spines on the under surface up to 1 inch in length, spines often flattened, tips fimbriate.

Thümen, *Zeitschr. Pflanzenkr.*, vol. i. p. 132.

Oak rot (*Hydnum diversidens*, Fries.) causes a white-rot of the wood of oak, beech, elm, birch, etc. It is a rare fungus

FIG. 121.—*Hydnum scheidermayeri.* Fungus, about one-quarter nat. size.

in this country. I have only met with it once, on a living beech in Epping Forest. It is a wound-parasite, entering through a broken branch and rapidly spreading in all directions. Wood attacked by the mycelium assumes a reddish-brown colour first; soon, however, the spring wood of each

year changes to a peculiar greyish-yellow tint, so that in a longitudinal section the wood presents a series of alternating stripes of colour, the larger medullary rays retaining the brown tint longest. The fruit of the fungus eventually appears on wounded branches, or comes to the surface of the trunk in places where the bark is destroyed.

The form of the sporophore varies much, depending on the conditions under which it is developed. When growing on a large surface, as a trunk it often extends for a considerable distance without forming a true pileus, but remains as an irregular, flattened patch. When growing on a branch it is often more or less knobbed or lobed, sometimes with an attempt at a stalk, whitish or tinged yellow, 2-3 in. across, upper surface with irregularly notched teeth or spines, edge with club-shaped, sterile teeth, under surface with pointed spines 3-6 in. long.

Hartig, *Die Zersetzungersch. des Holzes*, p. 97, pl. xi.
Prillieux, *Malad. des Plantes Agric.*, 1, p. 321 (1895).

THELEPHORACEAE

Sporophore erect and stipitate, partly reflexed or entirely adnate to the substratum ; hymenium even, smooth, and polished, or with projecting cystidia ; spores hyaline or coloured.

HYPOCHNUS (Persoon)

Mycelium forming a loosely interwoven weft spreading over the surface of the substratum. Basidia constantly 4-spored, arising in scattered tufts over the surface of the layer of mycelium.

Differs from *Exobasidium* in the superficial mycelium, and in the basidia constantly bearing four spores at the apex. *Corticium* differs in having a compact, waxy hymenium, consisting of closely packed basidia.

Potato collar fungus (*Hypochnus solani*, Prill. and Del.) forms a very thin, greyish, or fawn-coloured film round the living haulms of potatoes. This film begins at the point where the haulm emerges from the ground, and extends upwards for three or four inches. It consists of a loosely

interwoven mesh of stout, much branched, septate hyphae, from which spring here and there small tufts of basidia. This fungus has been stated by an American mycologist to be the fruiting condition of *Rhizoctonia violacea* (Tul.). I have met with this fungus on potatoes many times, but could not trace any connection with *Rhizoctonia*. This subject is discussed in more detail under *Rhizoctonia*.

When the spores of *H. solani* are sown on the cut surface of a potato tuber, a dense uneven crust of mycelium is produced, and the surface eventually becomes covered with scattered tufts of basidia. There is no approach to a compact hymenium, as in the genus *Corticium*, and all the mycelium remains perfectly colourless.

I have never noted any injury arising from the presence of this fungus on potato haulms, in fact the entire film is readily removed by slight rubbing, and I have not succeeded in detecting haustoria in the epidermal cells of the host.

Prillieux and Delacroix, *Bull. de la Soc. Mycol. de France*, 1891.

Cucumber collar rot.—This mischief is caused by *Hypochnus cucumeris* (Frank), and is not uncommon in this country, although I am not aware that it has been previously recorded as a British fungus. It attacks the stem at the soil level, and covers it with a thin greyish film of interwoven hyphae for a distance of three to four inches. The mycelium penetrates the tissues and soon chokes up the vessels, etc., thus cutting off the supply of food and water. When a plant is attacked the leaves wilt and turn yellow, and the stem collapses within a few days.

Frank says that this fungus also attacks clover and lupins.

The mycelium forms a very thin, inseparable stratum, loose and fibrous in texture, basidia scattered, cylindric-clavate, spores elliptical, $7\text{-}8 \times 5\ \mu$.

The only practical method of guarding against this disease is by destroying the mycelium or spores present in the soil; this may be done to some extent by mixing it with kainit some time before it is used. Leaf mould is most likely to contain the fungus. When the disease attacks the plants, it may be checked to some extent by watering with a solution of sulphate of potash.

Frank, *Hedwigia*, 1883; and in *Ber. d. deutsch. Bot. Gesell.*, 1883.

Tea leaf felt.—Bernard describes an injury caused to the leaves of *Thea assamica* in Java by an undescribed species of fungus, which he names *Hypochnus theae*. It forms a thin reddish-white weft or hymenium on the young twigs and on the under side of the living leaves. The fungus is not a parasite, but when it occurs in quantity the stomata are stopped up, causing the shoots to dry up, and the leaves to fall.

Basidia 20-25 × 6-8 μ, sterigmata 4, 6-8 μ long; spores hyaline, smooth, 7-9 × 5-7 μ.

It is recommended that diseased shoots be removed and burned, and the bushes sprayed with Bordeaux mixture.

Bernard, Ch., *Bull. Departm. Agric. aux Indes Néerland*, No. 6, p. 55 (1907).

Leaf blight.—Apple, pear, quince, plum, and other orchard fruits have suffered to a serious extent in Brazil and the United States from the presence of *Hypochnus ochroleucus* (Noack). During the early stage of the disease the symptoms resemble those due to 'fire blight,' caused by *Bacillus amylovorus* (De Toni), that is the leaves on numerous shoots are dead. In 'fire blight,' however, the dead leaves usually stand erect, whereas in the present instance they hang down in clusters. The injury caused by leaf blight is further confined to the leaves, the twigs not dying as in the bacterial disease. At a later stage the leaves fall away, leaving the shoots naked. Careful examination of a tree attacked by leaf blight reveals the presence of roundish sclerotia on the branches, 3-4 mm. in diameter, whitish at first then chestnut brown in colour. These are formed in abundance on the shoots of the year, especially on the lower shaded side, but occur sparingly or not at all on the petioles and leaves. Sclerotia are rarely found upon the fruit. In addition mycelial ribbons or rhizomorphs extend lengthwise along the twigs and petioles. These structures usually remain unbranched between the nodes, though they sometimes branch, the branches often anastomosing to form a network. On the blade of the leaf the bands of mycelium open out to form a more or less dense network of mycelial threads, which often run out so fine as to be invisible to the naked eye.

These rhizomorphs are white at first, gradually changing to a glistening brown colour. In some instances a compact hymenial layer is formed on the under surface of the leaves;

this is more completely interwoven into a tissue than the sterile portion, and can be stripped off the leaf as a thin film. The basidia are scattered on the hyphae and bear four sterigmata at the apex. Spores elliptic-oblong, 10·5-11·5 × 4·5-6 μ.

Sclerotia are not produced on the leaves, where they would be but of little service, whereas they are developed in abundance on the twigs, more especially near the tip, where they are best situated for perpetuating the species, serving as starting-points for the invasion of new shoots by the rhizomorphic strands of mycelium. Spore formation is rare.

It is considered that the parasite, being entirely superficial upon the twigs, and depending but to a slight degree upon spores, would be checked and destroyed by spraying in the spring.

Stevens, F. L., and Hall, F. G., *Ann. Mycol.*, 7, p. 49 (1909).

CORTICIUM (Fries.)

Hymenophore entirely adnate to the matrix, often broadly effused, hymenium smooth, polished, no cystidia present; spores colourless.

Corticium comedens (Fries.) is one of the commonest of saprophytic fungi occurring in this country. Rostrup has stated that it is also a wound parasite on the younger branches of the oak. The fungus is readily distinguished by originating and spreading for a considerable distance under the bark, which is eventually thrown off, exposing the hymenium of the fungus.

Broadly effused and inseparable from the matrix, exposed by the rupture of the bark of the host, dingy lilac, bleaching almost white, spores sausage-shaped, slightly curved, 14-16 × 6-7 μ.

Corticium scutellare (Berk. and Curt.) has been accused of parasitic habits, but no direct evidence is forthcoming. It grows on wood, herbaceous stems, etc.

Broadly effused, thin, inseparable from the matrix; dirty tan or tawny, becoming cracked in an areolate manner, spores elliptical, 5 × 3 μ.

A bark disease of hevea, tea, cinchona, etc (*Corticium Zimmermannii*, Sacc. and Syd.) is stated by Petch to be widely spread throughout the tropics, attacking, in addition to the

trees enumerated above, the orange, cacao, cinnamon, mango, pepper, ramie, and other plants of economic value, and many other shrubs and trees of minor importance. The fungus causes a bark disease, characterised by the production of superficial pink patches of fungus tissue. On *Hevea brasiliensis* the fungus generally originates at the fork of a tree, or where several branches arise close together from the main

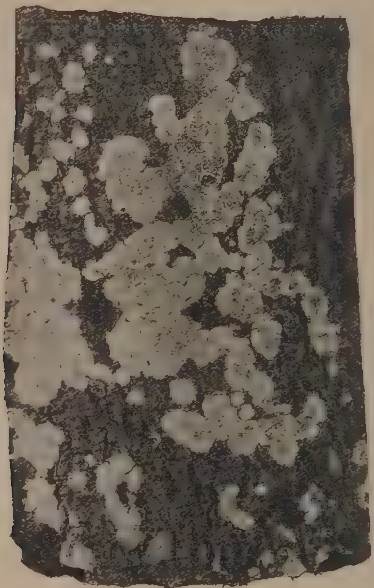

FIG. 122.—*Corticium scutellare.* Fungus on wood, nat. size.

stem. The fungus is at first usually superficial on the bark and can be scraped off without injury. The pink patch gradually extends, and may eventually cover the entire circumference of the tree and the bases of adjacent branches.

In the case of young trees growing in wet districts the fungus appears to grow continuously, and kills off the bark uniformly. The side branches are ringed and killed, and the

bark of the main stem peels off in large flakes. On the tea plant the fungus first appears on the smaller twigs and gradually spreads down to the thicker branches, where it is at first quite superficial, but the hyphae gradually penetrate and kill both bark and cambium. In the majority of instances the pink incrustation is permanent, but when old it cracks into lines more or less at right angles to each other, and loses its pink colour, fading to ochraceous or almost white. Sometimes the fungus causes the bark to die off in patches, which afterwards form cankers that enable other species of fungi to gain an entrance into the tissues of the host.

C. Zimmermannii, Sacc. and Syd. (= *C. javanicum*, Zimm., now *C. javanicum*, Sacc. and Syd.). Membranaceous, sometimes broadly effused, flesh-colour or yellowish, loosely adhering by hyphae to the matrix, basidia clavate, 4-spored, sterigmata slender, 4-6 μ long; spores piriform, apiculate, hyaline, $9\text{-}12 \times 6\text{-}7\ \mu$.

Petch, T., *Circ. and Agric. Journ. Roy. Bot. Gard., Ceylon*, vol. iv. No. 21, July 1909.

STEREUM (Pers.)

Furnished with a central stem, dimidiate or entirely resupinate, hymenium even, originating from a compact subhymenial layer; spores hyaline or tinted; basidia tetrasporous.

Differs from *Corticium* in the distinct subhymenial layer.

Stereum wood rot (*Stereum hirsutum*, Fries.) is one of our commonest of saprophytes, growing on dead trunks, stumps, etc. Hartig has shown that not infrequently it lives as a true and very destructive parasite on different kinds of broad-leaved trees. It is a wound-parasite, and the mycelium having gained access to a living tissue, continues to extend until the whole is destroyed. Wood that is attacked becomes pale brown first, then changes to yellowish-white. The thickening of the cell-walls is first dissolved and used by the fungus, the intercellular plates alone remaining, and these are eventually dissolved. Ward studied this fungus, and added considerably to the account previously given by Hartig. He also succeeded in growing the fungus as a pure culture, from the spore to the sporophore.

Wholly resupinate, or most frequently reflexed, the free portion projecting from the matrix, often crisped and lobed, coarsely fibrous above, dingy ochraceous; hymenium smooth, bright ochraceous; spores elliptical, hyaline.

It is difficult to suggest preventive measures against a fungus present practically everywhere. When growing on a

FIG. 123.—*Stereum hirsutum.* 1, fungus; 2, section of same; 3, basidia bearing spores, highly mag.

living tree it should be cut away, and the wound coated with gas-tar.

Hartig, *Die Zersetz. des Holzes*, p. 129.
Ward, *Trans. Roy. Soc.*, 189, p. 123 (1898).

Partridge wood (*Stereum frustulosum*, Fries.) is often a pure saprophyte; on the other hand, under certain conditions it assumes the nature of a destructive parasite, attacking various forest trees, more especially the oak. Dr. Hartig has

carefully studied the effect produced by the fungus, and shows that it is very characteristic and distinct from that produced by any other fungus. When the wood is first attacked it changes to a clear brown colour, variegated with numerous white patches, somewhat resembling the plumage of the breast of a partridge. At a later stage the white patches become holes in the wood, lined by the white mycelium of the fungus. The

FIG. 124.—*Stereum frustulosum*. 1, group of fungi on a piece of oak wood; 2, section through fungus, showing stratification; 3, basidia with spores, and two paraphyses. Fig. 1 slightly reduced; 2, slightly mag.; 3, highly mag.

remaining portions of wood become darker in colour, and very hard. At a later stage the diseased wood presents the appearance of having been riddled by insects.

Tuberculose, woody, crowded, looking like one much cracked specimen, under surface and glabrous margin brownish-black, substance distinctly stratified; hymenium convex, cinnamon, then pale, primrose; spores elliptical, ends subacute, $4{\cdot}5 \times 3\text{-}3{\cdot}5\ \mu$.

Diseased patches should be cut out until sound wood is reached, and the wound at once coated with gas-tar. As

the fungus also grows on fallen wood, all such should be removed.

Hartig, *Zersetz. des Holzes*, p. 103.
Prillieux, *Malad. des Plantes Agric.*, 1, p. 307 (1897).

Oak canker.—Professor Potter has indicated a canker of the oak, caused by *Stereum quercinum* (Potter). The fungus appears to be a wound-parasite, and causes a canker by the destruction of the cambium year by year, by which the formation of wood and bast is prevented, the result being a canker-like wound, surrounded by a rugged wall of callus surrounding a wound that never heals up. The parasite is most active during the winter, and destroys the cambium and wood formed during the summer. The entrance of the parasite is usually effected around the insertion of a dead branch. A series of cultures, extending over several years, clearly proved that the fungus first observed on cankered spots was the primary cause of the disease.

The action of the parasite on the wood is specially noticeable in the brown discoloration of the medullary rays. The appearance of 'partridge wood,' characteristic of the action of *Stereum frustulosum*, is not produced by *S. quercinum*.

Sporophore resupinate, with slightly raised edge, pale grey to pale brown, often with a lighter margin, $\frac{1}{2}$-$\frac{3}{4}$ in. across, only two hymenial layers present in old specimens, basidia smooth; spores elliptical, $8{\cdot}5 \times 4{\cdot}3\ \mu$.

Potter, *Trans. Engl. Arbor. Soc.*, p. 105 (1901-02).

Stereum rugosum (Fries.), although often living as a saprophyte, can also live as a parasite, and is especially destructive to the cherry-laurel, which in some districts cannot be grown on account of this pest. The cherry-laurels in the Queens' Cottage Grounds, Kew Gardens, are much injured.

Broadly effused, sometimes shortly reflexed, coriaceous, then rigid, pale greyish-yellow, changing to red when bruised or scratched; spores elliptical, 11-12×4-$5\ \mu$.

CLAVARIACEAE

A primitive type of the Basidiomycetes. In the simpler forms consisting of a simple, erect, club-shaped body, covered everywhere with the hymenium; in the higher forms the

club becomes branched, or may be divided into numerous branches.

Beetroot rot.—Prillieux calls attention to a disease said to be very destructive to beetroot in Spain. The mycelium covering diseased beetroot received from Spain was found by Prillieux to attack and rapidly destroy sound beetroots and carrots when infected with it. The mode of action of the fungus was identical with that of the species of *Sclerotinia*. Those portions of beetroot attacked by the mycelium of the parasite contained numerous minute sclerotia, known at one time as *Sclerotium semen*. This sclerotium is known to belong to *Typhula variabilis* (Riess.). The *Typhula* was not met with on the beetroot material, hence it is not absolutely certain that *T. variabilis* is the cause of the injury, as other species of *Typhula* also produce somewhat similar sclerotia.

The sclerotium is about 2 mm. diameter, white at first, gradually changing to brown, circular or oval, depressed, resembling a seed, hence the specific name when it was considered as a distinct species. Common on dead leaves, more especially those of poplar, when lying in heaps in a damp place. In course of time the sclerotium produces a slender, whitish, slightly club-shaped body 1·5-3 cm. high. Spores subcylindrical, ends rounded, hyaline, $6\text{-}7 \times 2{\cdot}5\text{-}3\ \mu$.

Prillieux, *Malad. des Plantes Agric.*, 1, p. 304 (1895).

EXOBASIDIACEAE

The most primite group of the Basidiomycetes. All the species are obligate parasites; the mycelium is immersed in the substance of the host, the basidia bursting through the epidermis.

Mostly parasitic on leaves of plants belonging to the Ericaceae more especially, analogous in habit with the Exoascaceae, belonging to the Ascomycetes.

EXOBASIDIUM (Woronin)

Parasitic on living plants, more especially the leaves. Forming galls or blisters that usually become red. Basidia bearing a variable number of sterigmata; spores elongated, continuous, hyaline. Conidia are present in some species.

Most closely allied to *Hypochnus*, differing in being parasitic, with immersed mycelium, and in the basidia bearing a variable number of spores.

Rhododendron galls (*Exobasidium rhododendri*, Cram.) form on the living leaves of *Rhododendron hirsutum*, *R. ferrugineum*, *R. Wilsonianum*, etc., and vary in size from

FIG. 125.—*Exobasidium rhododendri*, on leaves of *rhododendron*, slightly reduced; 2, basidia and spores of same, highly mag; 3, *Hypochnus solani* on lower part of a potato haulm, slightly reduced; 4, mycelium and basidia of *Hypochnus*, highly mag.

a pea to that of a cherry. These are at first pale green, at length often becoming red or brownish. When full grown the surface is covered with a delicate whitish bloom, due to the presence of innumerable minute conidia, produced by budding in a yeast-like fashion from the basidiospores. The mycelium is very abundant between the cells at the periphery of the gall, but scanty elsewhere. Small globose haustoria are present in the cells of the host.

Basidia covering the surface of the galls, clavate, sterigmata

large, 1-4 in number, spores sausage-shaped, hyaline, 11-13 $\times$ 5-6 μ. Conidia hyaline, cylindrical, 7-8 $\times$ 1 μ.

The life history of this fungus is not known. I have not observed mycelium present in the stem bearing diseased leaves, and its spasmodic appearance, at all events in this country, is not favourable to the idea of resting mycelium. I have observed it at infrequent intervals in Kew Gardens, but never twice on the same bush, and am altogether at a loss to account for its presence. Leaves bearing galls should be removed and burned.

Vaccinium leaf blister (*Exobasidium vaccinii*, Woron.) forms large blisters on the living leaves, less frequently on the petioles and young shoots of the bilberry, or whortleberry (*Vaccinium myrtillus*). Red or purple patches appear on the upper surface of the leaves, the fruit of the fungus appearing as a delicate white bloom, occupying corresponding patches on the under surface of the leaf.

The spores are narrowly fusiform, hyaline, 5-8 $\times$ 1-2 μ.

The fungus occurs on other species of *Vaccinium*, *Andromeda*, and *Acrostaphylos* in other European countries. Of no importance as a parasite.

Vine leaf blister (*Exobasidium vitis*, Prill. = *Aureobasidium vitis*, Viala and Boyer) has proved destructive in French vineyards from time to time. Small spots first appear on the grapes, which soon shrivel and die before attaining full size. The flesh is found to be completely permeated with mycelium. Livid patches first indicate the presence of the fungus on the leaves. These patches, also those on the fruit, are covered with a white bloom when the fungus is fruiting. Leaves that are attacked assume a deep red colour and fall early. The basidia are cylindric-clavate, and bear a varying number of sterigmata, 2-9, mostly at the apex, but sometimes a few are lateral. Spores variable in form and size, 12-16 $\times$ 4-6·5 μ. These spores, according to Prillieux, germinate by budding in a yeast-like manner, and may prove to be conidia, preceding the true basidiospores. Only recorded from France.

Prillieux, *Malad. des Plantes Agric.*, 1, p. 298 (1895).
Viala and Boyer, *Comp. Rend.*, 1891, p. 1148.

Var. *tuberculatum* (M'Alpine). In this variety more or

less of a stroma is present on the surface of the host, from which the basidia spring.

Widely diffused in Victoria, Australia, on the vine.

Var. *album* (Montem). A variety founded on the whitish colour of the fruiting stage of the fungus. In the typical form this is yellowish, and the mycelium is clear yellow just under the skin of the fruit.

On leaves and fruit-stalks of the vine in Austria.

Blister blight of tea plant is due to *Exobasidium vexans* (Massee). This disease is described by Dr. (now Sir George) Watt, as 'one of the very worst blights on tea. Is known to the planters as blister blight. I have seen hundreds of acres completely ruined by it.' The foliage is the part principally attacked, although young shoots are also sometimes infected. On the leaf the first indication of infection is the appearance of a small pink spot, which gradually increases in size. At this point the upper surface of the leaf becomes depressed, forming a rounded pit. A corresponding bulging out is present at the same point on the under surface of the leaf; several such pits may be present on a leaf. Eventually the convex surface of the blister becomes covered with the fruit of the fungus, under the form of a very delicate velvety pile. Conidia are first produced, followed by basidiospores borne on basidia.

Conidia produced on slender conidiophores before, or mixed with the basidiospores, 1-septate, slightly constricted, fusiform, $14\text{-}16 \times 5\text{-}6\ \mu$. Basidia cylindrical, bearing two sterigmata, spores ovate-oblong, continuous, hyaline, $5 \times 3\ \mu$.

Dr. Watt states that the disease invariably appears on tea that has not been pruned in the autumn, and about April it extends to pruned tea, which has by then come into leaf. This statement suggests, unless there is some very strong reason to the contrary, that where the disease is prevalent, autumn pruning should be practised.

Massee, *Kew Bulletin*, 1898, p. 109.
Watt, *The Pests and Blights of the Tea Plant*, p. 419.

Exobasidium lauri (Geyl.) causes branched, antler-like outgrowths, two or three feet in length, to spring from the leaves of *Laurus nobilis*, and *L. canariensis* in Italy and the Canary Islands.

Exobasidium andromedae (Peck.) causes similar features

on the foliage of *Andromeda polifolia*, in the United States, to those produced by *E. vaccinii* (Wor.) on *Vaccinium vitis-idaea*, and *V. myrtillus* in Europe.

Exobasidium Peckii (Halst.) This species attacks the flowers of *Andromeda Mariana* in the United States. The bell-shaped corolla is much distorted, and often converted into a polypetalous condition. The ovary also often becomes elevated above the receptacle.

Exobasidium japonicum (Shirai). This species forms galls on *Rhododendron indicum* which are superficially indistinguishable from those caused by *E. rhododrendi*. The galls either appear on the leaves, or the whole of a terminal bud may be involved.

It is considered by some as a distinct species, on account of the difference of host, and difference in the size of the spores, but it seems to be rather doubtful, as the host argument is valueless, and in all known species the spores vary much in size.

Spores $14{\cdot}5 \times 4\ \mu$.

Chittenden, *Journ. Roy. Hort. Soc.*, 34, p. 45 (1908).

Exobasidium Fawcettii (Massee). This species forms very large galls and curiously shaped malformations on the leaves and buds of *Lyonia jamaicensis* in Jamaica, where it is very common. Spores spindle-shaped $15\text{-}16 \times 4\text{-}4{\cdot}5\ \mu$.

The majority of species are parasitic on plants belonging to the Ericaceae, but some of no economic importance attack species of saxifrage, grasses, *Symplocos*, etc.

HEMIBASIDIOMYCETES

A small group until recently included in the Basidiomycetes, distinguished by the basidia having 2-4 transverse septa, each cell of the basidium giving origin to a one-celled spore.

HIRNEOLA (Fries.)

Substance between cartilaginous and gelatinous, soft when moist, rigid when dry but reviving when moistened. Sporophore ear-shaped, veined, externally velvety. Basidia rod-shaped, transversely septate, each cell bearing one hyaline, continuous spore.

Substance thin, translucent.

Hirneola auricula-judae (Berk.), commonly known as Jews' ear fungus, is parasitic on the elder. It has also been recorded as occurring on elm. Prillieux and Delacroix state that it is a wound-parasite, attacking the mulberry in France.

Irregularly human ear-shaped, pliant like thin india-rubber when moist, rigid when dry. Externally with delicate greyish-white silky down, sessile, clustered, 4-7 cm. across. Spores reniform, $20\text{-}25 \times 7\text{-}9\ \mu$.

Of no importance as a parasite. Grows on elder, which it is said to kill.

Hirneola polytrichna (Mont.), an allied species, is not a native in this country, but is sometimes met with on imported wood. It is a source of revenue in New Zealand, being exported to China as an article of food, where it is considered as a delicacy.

HELICOBASIDIUM (PAT.)

Resupinate, incrusting, soft, basidia straight when young, then curved, transversely septate, bearing a spore from each cell of the basidium; spores hyaline, 1-celled.

Mulberry root rot.—According to Tanaka the mulberry-tree, which is cultivated on a large scale in Japan for rearing silkworms, is subject to a very serious disease caused by a fungus called *Helicobasidium mompa* (Tanaka). The root is first attacked, and when the fungus is established its presence is indicated by the growth of the shoots being arrested, the small size of the leaves, and their wilting and finally dying. The shoots also die later in the season. The lowest roots are the first to succumb, the tree endeavouring to reinstate itself by the formation of others higher up, these in turn are attacked, and the tree is usually killed in about three years. The diseased roots are felted over with a network of mycelial strands of a purplish-brown colour, some of which spread in the soil. When the fungus is well established on the root it emerges above ground, it gradually ascends the trunk and lower branches, which become covered with a thin felt of dark brown mycelium having a paler, growing margin. Eventually certain portions of the fungus spread out at right angles to the substratum. The hymenium, which is of a whitish colour, is produced on the free portions. Numerous sclerotia are found in the decaying roots.

Hymenium whitish, basidia more or less curved, 1-3 septate, each cell of the basidium bearing one spore; spores elliptical, curved, hyaline, $10\text{-}12 \times 5\text{-}7\ \mu$.

Tanaka, *Journ. Coll. Sci. Imp. Univ. Japan*, 4, pt. 1, p. 193, pl. 24-27 (1891).

DEUTEROMYCETES

The members of the present group have of late years been considered as representing conidial forms of higher fungi, and in fact so many of these fungi have been definitely proved, by means of carefully conducted pure cultures, to be in reality phases in the life-cycle of fungi belonging to the Ascomycetes and the Basidiomycetes respectively, that probably the supposition is quite correct. At present, however, there are many thousands of forms included in the present group that have not been actually proved to be connected with any higher form, hence it is necessary in the meanwhile to retain the names, if only as a matter of convenience, until they are definitely proved to be stages only in the life-history of other species.

From an economic standpoint, the members comprising the present group are perhaps more important than those belonging to any other section of fungi, as it is almost invariably the conidial or summer stage of a fungus that infects the host and causes a wholesale epidemic.

The Deuteromycetes are divided into three primary groups:—

1. *Sphaeropsidiaceae.* Conidia produced in a definite perithecium.

2. *Malanconiaceae.* Perithecia absent; conidia borne on a compact stroma or solid mass of hyphae that gives origin to crowded conidiophores bearing the conidia at their tips.

3. *Hyphomycetaceae.* Perithecia and stroma absent; conidiophores superficial, erect, often branched, and bearing the conidia at the tips of the branchlets.

Most of the species are quite minute, or, as usually termed, microscopic, and are often recognised by the blotches they form on leaves, fruit, etc., caused by the mycelium of the fungus killing or injuring the tissues in the affected area, the true fruit of the fungus appearing as minute dots or dark coloured points on the injured patches.

SPHAEROPSIDIACEAE

* *Spores continuous*

PHOMA (Fries.)

Perithecia subcutaneous then erumpent, globose or compressed, not beaked, mouth minute, conidia hyaline, continuous, elliptical to subglobose.

A numerous genus, the species forming crowds of black microscopic dots on stems and leaves.

Gooseberry shoot spot.—Numerous minute black dots nestling in the epidermis of gooseberry shoots, more especially

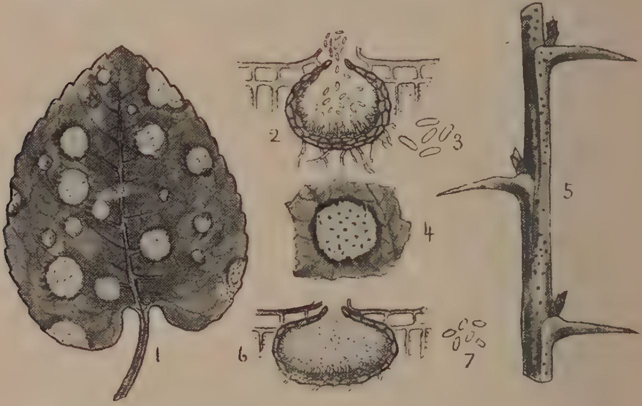

Fig. 126.—1, *Phyllosticta violae* on violet leaf; 2, section of a perithecium of *Phyllosticta*; 3, spores of same; 4, spot on violet leaf formed by the fungus; 5, *Phoma suspecta*, on gooseberry twig; 6, perithecium of same in section; 7, spores of same.

near the tip, are exceedingly common; in fact it is difficult to meet with a shoot of the season clear of these dots, which are the perithecia of *Phoma suspecta* (Mass.). This fungus is slightly, if at all, parasitic in its nature, and does no real injury, but is somewhat interesting as having been on many

occasions mistaken for the perithecia of the American gooseberry mildew.

Perithecia depressed, with a slightly prominent darker mouth, 125-150 μ diam. Spores elliptical, $3·5$-5×2-$2·5$ μ.

Two other species of *Phoma* also occur on *Ribes*. *P. ribesia* (Sacc.), spores $10 \times 3·5$ μ, and *P. grossulariae* (Schulz. and Sacc.), spores 6-9×2-$2·5$ μ. These are not in any way injurious.

Dryrot of swede and mangold (*Phoma napobrassicae*, Rostr.) sometimes causes serious injury to the roots of swedes and mangolds, causing the appearance of large, dry cracks penetrating deeply into the flesh, and forming a suitable entrance into the tissues for other organisms.

Sporangia minute, black, appearing on the surface of the wounds. Conidia hyaline, 4-6×1-2 μ, emerging from the sporangium in a reddish, gelatinous tendril.

Diseased roots should not be left lying about, and it is important that such should not be stored along with other roots.

Potter, *Journ. Bd. Agric.*, 6, No. 4.

Rostrup, *Tidsskr. for Landökonomi*, R. 5, Bd. 2, p. 330 (1891).

Lobelia canker.—This very destructive disease to cultivated lobelias was first described by Berkeley fifty years ago, under the name of *Phoma devastatrix*. The very minute perithecia appear in myriads on the stems, giving them a cankered appearance. Spores elliptical, 8-10×4-5. In some instances the spores become 1-septate, suggesting the genus *Ascochyta*.

Diseased plants should at once be removed, as they never bloom.

Cabbage stem rot.—A destructive disease brought about by *Phoma brassicae* (Thüm.). The stem is the part attacked, the parasite forming large, roundish patches bordered with brown and becoming pale towards the centre. Very frequently these patches extend into each other forming large, irregular markings. The central portion of the patch becomes studded with the minute perithecia of the fungus. The tissue of the stem underlying each patch becomes brown and dead, the injury extending to the centre of the stem. When a plant is attacked the leaves soon turn yellow, and the whole plant perishes within a short time.

The perithecia are globose-depressed, the opening or mouth alone bursting through the epidermis. Conidia very minute, cylindrical, 3-4 × 1·5-2 μ.

The only means of checking an epidemic is to promptly remove and burn diseased plants.

Prillieux, *Malad. des Plantes Agric.*, 2, p. 295 (1897).

Carrot disease (*Phoma sanguinolenta*, Rostrup) forms greyish-brown, canker-like wounds that eat deeply into the root of the carrot. The mycelium persists in the root, and during the following season passes up into the flowering stem, which here and there shows depressed areas covered with the fruit of the fungus.

Perithecia gregarious on depressed areas of the flowering stem or on canker-like wounds on the root; conidia 4-6 × 1·5-3 μ, escaping through the mouth of the perithecium in the form of a red, viscid tendril.

Diseased roots should not be planted for seed, as the flower stem becomes diseased, and no seed is produced. Neither should diseased carrots be mixed with sound ones when storing, as the disease spreads by contact.

Rostrup, *Zeitschr. Pflanzenkr.*, 1894, p. 195.

Squirt berry (*Phoma tuberculata*, M'Alp.) is the cause of a grape disease in Australia. The fruit is the part attacked, and when diseased grapes are gently pressed between the fingers, the contents are readily squirted out, hence the popular name of the disease. Diseased grapes first show a circular ashy-grey or slaty-blue patch dotted with numerous minute pustules. Eventually the berries become partially dry, but remain pliant.

Stroma of fungus more or less columnar, bearing the perithecia on its surface. Conidia oblong or ovate, minute.

M'Alpine, *Add. to Fungi of Vine in Australia*, p. 23.

Phoma hennebergii (Kühn) often proves destructive to the wheat crop, attacking the glumes and causing the ear to shrivel. The fungus also sometimes attacks the leaves.

Perithecia scattered on brown spots, erumpent, rounded, black, about 100 μ in diam., conidia cylindrical, sometimes slightly curved, 14-18 × 2-2·5 μ.

Phoma solani (Halsted) causes a 'damping off' of egg-plants. The disease attacks the seedlings at the base of the stem, the fruit of the fungus appearing as exceedingly minute dots on the diseased part.

Halsted, *New Jersey Agric. Exp. Sta. Rep.*, 1891.

FIG. 127.—*Phoma sanguinolenta.* 1, diseased carrot; 2, diseased carrot flowering stem; 3, portion of a diseased spot showing perithecia with the conidia escaping as a viscid tendril; 4, section of a perithecium with the conidia oozing out in a tendril. Figs. 1 and 2 reduced; remainder mag.

Phoma solanicola (Prill. and Del.) attacks the haulm of the potato, forming large, oblong, whitish or clear yellow spots, which eventually become dotted over with the minute, blackish perithecia of the fungus. When the lateral branches are attacked the leaves soon wither, and when several branches are attacked the plant does not obtain the required

amount of food, and the growth of the tubers is more or less checked.

Perithecia immersed in the tissue of the host, 130-145 μ diam. Conidia elliptic-oblong, $7 \cdot 5 \times 3$ μ.

Prillieux, *Malad. des Plantes Agric.*, 2, p. 296 (1897).

MACROPHOMA (Sacc.)

Only differs from *Phoma* in the larger conidia and unbranched conidiophores.

Yew leaf blight (*Macrophoma taxi*, Berl. and Vogl.) attacks living leaves of *Taxus baccata*, causing them to turn brown, but they do not fall for some time. Not infrequently whole branches are attacked, and are very conspicuous.

The small black, sunken perithecia are scattered on the under surface of the leaf, or sometimes arranged in an irregular line on each side of the midrib. A few perithecia are sometimes present on the upper side of the leaf. Spores elliptic-oblong, $20\text{-}24 \times 9\text{-}12$ μ.

Attacked branches should be removed to prevent further infection.

PHYLLOSTICITA (Pers.)

Perithecia formed under the epidermis, lenticular, membranaceous, mouth or pore of dehiscence often protruding, seated on discoloured spots on leaves, rarely on shoots; conidia minute, elliptical or oblong, continuous, hyaline or tinged with olive.

Australian shot-hole fungus (*Phyllosticta prunicola*, Sacc.) attacks living leaves of apple, pear, plum, cherry, apricot, etc., producing effects similar to those due to the European shot-hole fungus (*Cercospora circumscissa*). Small brownish spots first appear on the upper surface of the leaves, which become dry and brittle, and eventually drop out, giving to the leaf the appearance of having been riddled with small shot. Very minute perithecia are formed on the diseased spots. The fungus occurs in Western Europe, United States, and in Australia.

Perithecia scattered, dot-like, slightly prominent; conidia ovoid or elliptical, dilute olive, 5×3 μ.

Usually not very destructive, unless especially abundant on young stock, when spraying with Bordeaux mixture is recommended.

Apple blotch.—Scott and Rorer have quite recently described a serious disease attacking apples in the United States. The injury is caused by *Phyllosticta solitaria* (Ellis and Everh.). The fungus forms cankers on the young shoots; irregular, light brown, yellowish, or whitish, quite small patches on the leaves; and blackish, irregular patches on the fruit, the surface of which often cracks in consequence. Minute black perithecia are produced in abundance on diseased spots, both on twigs, leaves, and fruit. The first spring infection is due to spores produced on infected twigs.

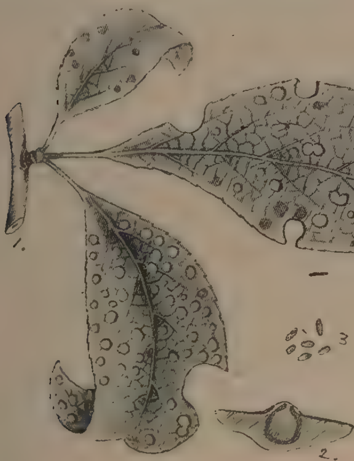

FIG. 128.—*Phyllosticta prunicola.* 1, apple leaves attacked by fungus; 2, section through a perithecium embedded in the substance of the leaf; 3, conidia. Figs. 2 and 3 mag.

Perithecia minute, immersed in the matrix, the mouth alone rupturing the epidermis, appearing as minute raised points; conidia hyaline, broadly elliptical, continuous, surrounded by a mucilaginous sheath which runs out at one end of the conidium as a hyaline appendage, which is apt to be overlooked, $8\text{-}10 \times 5\text{-}6\ \mu$.

I have repeatedly met with perithecia containing conidia precisely similar to those described above, during the spring months, growing from the stroma-like portion of *Venturia*

chlorospora, better known as *Fusicladium dendriticum*, occurring on diseased apple twigs, but the perithecia were always associated with the *Fusicladium* stage of the fungus, producing its well-known conidia. The habit and general appearance of the American fungus seems to suggest the idea of its being identical with our apple scab. In the United States, or in those particular States where apple blotch is predominant, is the *Fusicladium* stage arrested, and the *Phyllosticta* stage alone produced; in Europe we know the opposite is the case. A similar condition of things is known to exist in the case of other parasites.

Spraying with Bordeaux mixture is recommended, of strength 4, 4-6·50. First application, just before blossoms open. Second, immediately after the petals fall. Third, three or four weeks after the petals have fallen. Fourth, eight or nine weeks after the petals have fallen. Fifth, two to three weeks after the fourth. Sixth, three weeks after the fifth spraying. This treatment is also said to cover bitter-rot. Remove diseased twigs and wounds in the bark of larger branches.

Scott, W. M., and Rorer, J. B., *U.S. Dep. Agric.*, *Bur. Pl. Ind.*, *Bull.* No. 144 (1909).

Phyllosticta cannabinis (Kirch.) forms more or less circular, tawny, then pale spots on the upper surface of hemp leaves, and when present in quantity the plants are seriously injured.

The perithecia forms small blackish dots on the bleached spots. Conidia hyaline, elliptical, sometimes slightly curved, $4\text{-}6 \times 2\text{-}2{\cdot}5\ \mu$.

Violet disease (*Phyllosticta violae*, Desm.) forms more or less circular bleached spots on the leaves; these gradually increase in size and often run into each other, forming irregular blotches which show equally on both surfaces of the leaf. At a later stage the fruit of the fungus, under the form of minute black dots on the bleached spots.

Perithecia minute, dark coloured, with a small pore or ostiolum at the apex; conidia hyaline, subcylindrical, $10\ \mu$ long.

Spraying with potassium sulphide checks the spread of the pest, if begun at an early stage. To ensure strong, vigorous plants, a period of rest in a cool frame is necessary.

Lilac leaf spot (*Phyllosticta syringae*, Westend.).—Very frequent on living leaves of lilac, forming irregularly shaped, rather large bleached spots surrounded by a brown border. The minute, blackish, dot-like perithecia, containing numerous minute hyaline, oblong conidia, averaging $8 \times 3\ \mu$.

This parasite is widely distributed in Europe, in fact its occurrence is that of its host-plant.

Phyllosticta idaecola (Cooke) forms rather indistinct brown spots with a whitish centre on living leaves of *Sida napaea* and various species of *Hibiscus* grown in houses. Conidia hyaline, elliptical, $4 \times 2\ \mu$.

Phyllosticta helleborella (Sacc.) forms large ill-defined blotches on the leaves of various kinds of hellebore. The blotches are blackish at first but soon become pale with a dark border, and studded with the minute, flattened perithecia. Conidia oblong, colourless, $7 \times 3\ \mu$.

Phyllosticta aceris (Sacc.) forms bleached spots on the leaves, which become studded with the small dot-like fruiting bodies. Conidia elliptical, $5 \times 3\ \mu$.

Phyllosticta cytisi (Desm.) forms circular bleached spots, that eventually turn brown, on laburnum leaves. Conidia oblong, $6 \times 3\text{-}4\ \mu$.

Phyllosticta primulaecola (Desm.) forms rather large whitish spots, with a tawny margin, on the leaves of *Primula vera* and *P. elatior*, and may possibly pass to other species. Conidia $4\text{-}5 \times 2\text{-}3\ \mu$.

Phyllosticta cornicola (D. C.) produces rather large, blood-red spots that become pale in the centre, on the leaves of *Cornus sanguinea* and other species. Conidia elliptic-oblong, $7\text{-}9 \times 3\text{-}4\ \mu$.

Phyllosticta apii (Halst.). This is figured and described in the *N. Jersey Agric. Exp. St. Rep.*, 1891, p. 253. It differs from *Cercospora apii*, in the spots on the leaf being dull brown, never pale coloured.

SPHAEROPSIS (Lév.)

Perithecia distinct, slightly carbonaceous; conidia continuous, escaping through a terminal pore.

Apple leaf spot.—Dr. W. M. Scott has shown that a serious disease affecting apple leaves is caused by *Sphaeropsis malorum* (Peck.) in the United States. It has also been recorded in

this country. It produces circular or irregular reddish-brown spots an eighth of an inch or more in diameter, often with a slightly raised purplish margin. When old the spots often become greyish. If the infection is bad the spots coalesce and form large brown patches involving half the leaf or more. It usually appears early in the spring, and fresh leaves become infected throughout the season. As a result the leaves fall early in the season, and if this is repeated for several years in succession, the trees become weakened, and the fruit is small and poor in quality.

Certain other fungi, such as species of *Hendersonia*, *Coryneum*, *Pestalozzia*, *Alternaria*, etc., often appear as saprophytes on the diseased patches caused by the *Sphaeropsis*.

Perithecia innate, erumpent; spores oblong, coloured, $25 \times 10\text{-}11\ \mu$, borne on sporophores of equal length.

Scott says that for the control of this disease alone an application of Bordeaux mixture should be made in the spring, a week or ten days after the petals have fallen, a second application four weeks later, and a third about four weeks after the second. Three applications are necessary only in exceedingly wet seasons in sections where the disease is severe. Ordinarily two treatments, one about three weeks after the petals are off and the other four or five weeks later, are sufficient.

A weak Bordeaux mixture, such as 3 pounds of copper sulphate and 3 pounds of lime to 50 gallons of water, is effective in controlling this disease, Bordeaux mixture of full strength not being required.

Scott, W. M., *U.S. Dept. Agric.*, *Bureau of Plant Industry*, *Bull.* No. 121, pt. 5 (1908).

CONIOTHYRIUM (CORDA)

Perithecia membranaceous, or rather rigid, dark coloured; spores minute, continuous, coloured, borne at the tips of short sporophores.

Very closely allied to the genus *Sphaeropsis*, differing mainly in the relatively smaller perithecia and spores, the only tangible difference consists in the sporophores in *Sphaeropsis* being elongated, whereas in *Coniothyrium*, the sporophores are very short or obsolete.

Hellebore leaf blotch.—Large, circular, brownish blotches formed, showing on both surfaces of living leaves of *Helleborus niger*, and may probably occur on other species. The blotches have a scorched appearance, and are studded with the minute blackish perithecia which are usually arranged in rings. Spores oval, pale brown, $4\text{-}5 \times 2\text{-}3\ \mu$. The parasite is called *Coniothyrium hellebori* (Cooke and Massee).

Cut off and burn infected leaves.

Yucca leaf blotch (*Coniothyrium concentricum*, Sacc.) forms greyish more or less circular dead patches, ranging from 1-3 cm. diam., on the living leaves of species of *Yucca*, *Agave* and *Fourcroya*. The minute blackish perithecia are often arranged in concentric circles on the dead spots, but not always. The spots themselves are frequently bounded by a darker brown line. Spores subglobose, becoming dark coloured, $4\text{-}5 \times 3\text{-}4\ \mu$.

Diseased leaves should be cut out, otherwise the fungus extends rapidly and causes much disfigurement.

Rose canker.—Large, irregular, cankered wounds are frequently met with on the stems of both wild and cultivated roses; their presence is due to *Coniothyrium Fuckelii* (Sacc.), which is considered by some as a conidial condition of *Leptosphaeria coniothyrium* (Sacc.). The disease commences on one-year-old wood, and its presence is revealed by small reddish patches scattered over the green bark. At a later stage, minute cracks appear at the injured points, and gradually continue to increase in size. At this stage the formation of callus begins, the cells of which are in turn attacked by the fungus, consequently the callus continues to grow and form large nodulose masses which may extend for many inches along the branch, forming the well-known canker.

If the irregular outgrowth forming a cankered spot is examined with a pocket-lens, numerous, very minute black dots will be seen; these are the fruit of the fungus. It is considered that frost aids in the formation of canker, after the fungus has first made a start. The fungus is a wound-parasite, the spores gaining access to the living tissue through small wounds made by the spines of the plant itself, when one branch is blown against another by wind, by insects, etc.

Perithecia black, depressed, scattered, $180\text{-}200\ \mu$ diam., spores minute, very numerous, $3\text{-}4 \times 2\text{-}3\ \mu$.

Sorauer, on the other hand, considers the disease under consideration to be primarily due to frost. Small radial cracks first appear in the bark, which gradually extend, and if the callus that is formed is afterwards injured by frost, a canker eventually results. I have at times met with such cankered spots, on which no fungus could be found.

Stems that are badly cankered should be removed and burned. Small diseased patches may be cut out, and the

FIG. 129.—*Coniothyrium Fuckelii*, forming canker on rose stems.

wound dressed with tar. Güssow, who first observed this disease, recommends that the earliest red patches indicating the presence of the fungus on the young wood should be painted with creosoted Stockholm tar.

The rose canker, so common on the wood of many kinds of roses, more especially Maréchal Neil, and often most abundant near the base of the stem near the junction of stock and scion, is of a physiological nature, and has nothing

in common with the disease under consideration, except the name of canker.

Güssow, *Journ. Roy. Hort. Soc.*, 34, p. 222 (1908).
Sorauer, *Zeitschr. Pflanzenkr.*, 17, p. 22 (1908).

Blackberry canker.—Large irregular nodules, varying in size from a marble to a walnut, are formed on the stem of the common bramble by *Coniothyrium tumaefaciens* (Güssow), a close ally of the fungus causing rose canker.

Perithecia blackish-brown, scattered; conidia unicellular, pale dirty green, elliptic, $5\text{-}7 \times 3\text{-}4\ \mu$, supported on long, simple or branched conidiophores.

Güssow, *Journ. Roy. Hort. Soc.*, 34, p. 229 (1908).

VERMICULARIA (Fries.)

Perithecia erumpent or subsuperficial, black, globoso-conical, membranaceo-carbonaceous, at length concave, with a mouth or mouthless, clothed with long, rigid, septate, dark hairs; conidia usually cylindric-fusoid, often inaequilateral, continuous, borne on variously formed conidiophores.

In some species the perithecia are imperfect or widely open and *Peziza*-like.

Onion scab (*Vermicularia circinans*, Berk.) is an erratic parasite, being very abundant during certain seasons, then mysteriously disappearing for a considerable time, and again suddenly appearing in profusion. As a rule but little real injury is done to the bulbs—the part attacked; yet the presence of numerous black blotches on the outermost coating much depreciates their sale.

The fungus usually appears when the bulbs are nearly full grown, under the form of scattered black patches, consisting of minute velvety tufts arranged in concentric circles or wavy lines. I find that the conidia readily infect onions the moment they are mature, the black tufts of spines appearing in about ten to twelve days. It is doubtful as to whether the minute conidia retain their vitality until the following season. Minute black microsclerotia are produced in the tissue of the bulb tunic under diseased spots, and these may probably continue the species in time. It is known that when diseased bulbs are stored along with healthy ones, the disease spreads

rapidly if there is the least sign of sweating, hence tainted onions should be thoroughly dried and used at once.

Spots orbicular, perithecia concentrically arranged, seated on radiating hyaline mycelium, very minute, furnished with long, rigid, black hairs; conidia oblong, hyaline, $10\text{-}14 \times 3\text{-}4\ \mu$.

Berkeley, *Gard. Chron.*, 1851, p. 595.
Stoneman, *Bot. Gaz.*, 1898, p. 98.

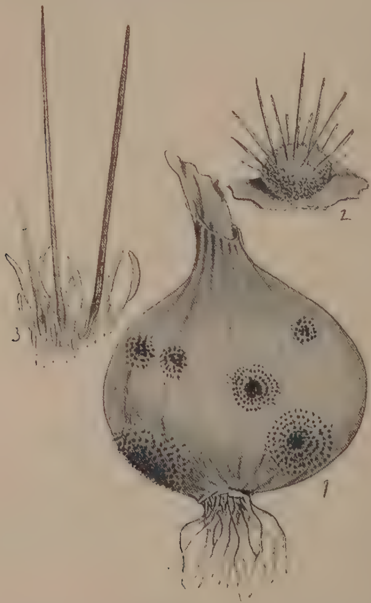

FIG. 130.—*Vermicularia circinans.* 1, onion attacked by fungus; 2, one of the black tufts of the fungus; 3, portion of a tuft showing the conidia borne at the apex of slender conidiophores, also the long black spines. Figs. 2 and 3 highly mag.

French potato scab.—Dr. Ducomet has described a disease of potatoes and tomatoes which when recurring on the tubers would come under our conception of scab, but which he terms 'dartrose.' The fungus causing the injury is *Vermicularia varians* (Ducomet). The disease, although present, is not

very obvious on fresh tubers, but after storing, when a certain amount of dessication has taken place and the surface has become rugged, minute black points—micro-sclerotia—become visible to the naked eye. These black points are the essential characteristics of the disease. In certain kinds of potatoes, where the skin constantly and normally peels off in small flakes, the black points are removed with the flakes, and it is difficult to observe the disease unless microscopic sections of the skin are examined. The root and stem are also attacked, and eventually become covered with black points. If an infected tuber is used as 'seed,' the mycelium often passes into the young tubers, which are killed. The young tubers may also become infected by sclerotia in the soil, if a diseased crop has been grown previously.

The general aspect of the disease, with the minute black sclerotia nestling in the epidermal cells, recalls to mind the scab caused by *Spondylocladium atrovirens*, but the fruit is different. The sclerotia eventually produce numerous black bristles, also hyaline conidia borne at the tip of hyaline conidiophores. According to the author the sclerotia become converted into a pycnidium at certain times, at others the fruit oscillates between *Phoma*, *Gloeosporium*, and *Colletotricham*. The mean of all these forms is described as follows by the author.

Vermicularia varians (sp. nov.). Pycnidia erumpent and superficial when mature, 75-150 μ, mouthless, furnished with black, rigid hairs, 100-130 $\times$ 3-4 μ, biseptate, slightly swollen at the base, attenuated and pale at the summit. Conidia slightly curved, acuminate, hyaline, guttulate, 18-22 $\times$ 2·5-3 μ; conidiophores hyaline or brown at base, 20-30 $\times$ 3-3·5 μ. A variable species.

Ducomet, *Ann. l'École Nat. d'Agric. de Rennes*, 1909, p. 24.

PYRENOCHAETA (De Not.)

Perithecium globose, partly immersed in the matrix, blackish, furnished round the mouth with spines; spores continuous, elongated, hyaline.

Often occurring on the stems or leaves of herbaceous plants. Considered as saprophytes generally, but in all probability many of the hosts are infected while in a living condition, the fruit of the fungus only appearing after death.

Phlox stem canker.—The stems of various cultivated kinds of *Phlox* are sometimes attacked just above the ground-line by *Pyrenochaeta phloxidis* (Massee), the result being a

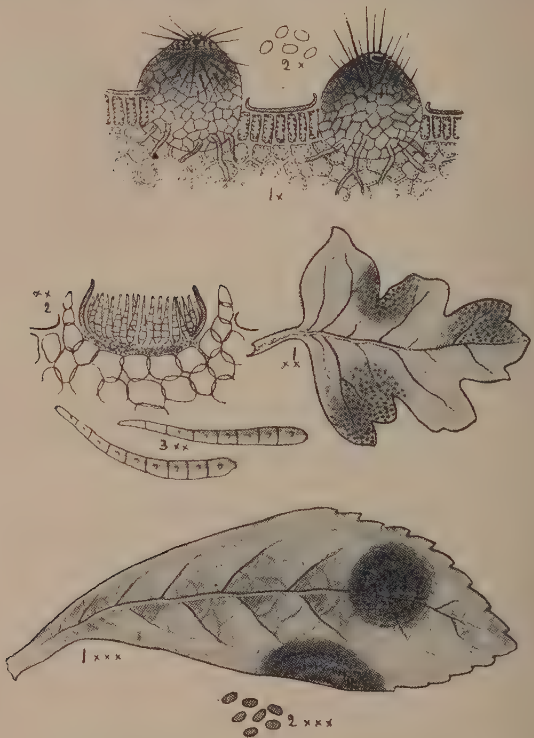

FIG. 131.—1 x, *Pyrenochaeta phloxidis*, section of phlox stem showing two perithecia, mag.; 2 x, spores of same, mag.; 1 xx, *Phleospora oxyacanthi*, on hawthorn leaf; 2 xx, section of spore-bed of same, mag.; 3 xx, spores of same, highly mag.; 1 xxx, *Coniothyrium hellebori*, on leaf of black hellebore; 2 xxx, spores of same, highly mag.

cankered appearance, which results in the death of the stem attacked. The leaves turn yellow and drop off, followed by the breaking of the stem near the base. The minute, black,

hairy perithecia of the fungus can be seen with the aid of a magnifying-glass.

Perithecia globose, partly buried in the substance of the stem, ornamented with long, black spines round the opening.

Spores elliptical, hyaline, 5×3 μ.

When plants are once attacked cure is impossible, as the mycelium is deeply seated in the tissues before its presence is indicated by the wilting and yellowing of the foliage. Diseased stems should be cut out and removed to prevent the spread of the disease.

Pyrenochaeta ferox (Sacc.) sometimes forms blackish patches on the fading stems of potatoes. Perithecia furnished round the mouth with more or less spreading, colourless spines. Spores cylindrical, 8-9 $\times$ 1 μ.

** *Spores* 1-*many-septate.*

SEPTORIA (Fries.)

Perithecia usually grouped on discoloured patches of living leaves, sunk in the tissue of the host with a projecting opening; spores long and slender, usually many-septate, hyaline.

Eighty-five British species are recorded; the majority grow on weeds and wild plants, and are of no economic importance. The discoloured spots on living leaves of many trees, herbaceous plants and weeds, are caused by species of *Septoria*.

Tomata leaf spot (*Septoria lycopersici*, Speg.) is responsible for this disease, whose presence in this country was first noted by Güssow. It was first observed on tomatoes in the Argentine Republic. The fungus attacks the fruit, stem, calyx, but more especially the leaves, which show small, blackish-green spots concentrically arranged; these spots soon become confluent, and the leaves, which are rapidly killed, curl up and hang loosely from the stem. The spots often become ashy-grey, and the numerous minute fungus fruits appear like fine black dots scattered over the diseased area.

Spores hyaline, filiform, slightly bent as a rule, 5-9-septate, 70-110 $\times$ 3 μ.

Güssow states that plants can be saved if sprayed immediately the disease is noticed, with a three per cent. solution

of Bordeaux mixture. A stronger solution injures the foliage. Badly attacked plants should be burned.

Güssow, *Journ. Bd. Agric.*, 1908, p. 111.

Carnation leaf disease.—Professor Potter has given an account of the ravages of *Septoria dianthi* (Desm.) on the leaves of cultivated carnations. The disease is recognised by the bleaching of the part attacked, which changes to a straw-colour and of a dull surface. Such discoloration is not localised, but extends from the point of infection along the whole surface of the leaf to the tip. The tissue becomes much shrunken and the leaf curls longitudinally. Full-grown leaves are most frequently attacked, but young leaves by no means escape; the nodes of the flowering-stem also suffer.

The fungus is a serious pest, and is well known to cultivators of carnations and pinks in Europe, South Africa, Australia, and the United States. It also occurs on several wild caryophyllaceous plants in Europe.

Perithecia immersed in the leaf, being produced in the substomatal cavities, with the mouth projecting above the surface of the epidermis, blackish; spores extended in a tendril-like, mucilaginous mass, hyaline, long and narrow, usually slightly curved, both ends obtuse, sometimes 1-septate, $30\text{-}45 \times 4\text{-}4{\cdot}5\ \mu$.

Prompt removal of infected leaves, accompanied by spraying with potassium sulphide is recommended.

Potter, M. C., *Journ. Roy. Hort. Soc.*, 27, p. 428 (1902-1903).

Brown spot of chrysanthemum leaves.—This disease, caused by *Septoria chrysanthemella* (Sacc.), is well known on the Continent and in the United States. It has also been recorded in this country by Salmon. The symptoms are the presence of brown spots on the leaves. Such diseased leaves usually become crumpled at the edges, and fall prematurely, the plant being thus not only disfigured, but also weakened in growth.

The subglobose, minute perithecia are immersed in the substance of the diseased spots, and appear as black points at the surface. Conidia hyaline, filiform, septate, $40\text{-}70 \times 1{\cdot}5\text{-}2\ \mu$.

Bordeaux mixture is recommended; but the unsightly appearance of this substance on the plants can be avoided by

spraying instead with a solution of copper sulphate in water—one pound to fifty gallons of water.

Halsted, *Rep. N. Jersey Agric. Coll. Expt. Sta.*, 1894, p. 363.
Salmon, *Rep. Econ. Mycol.*, *Wye Coll.*, 1908, p. 79.

Chrysanthemum leaf scorch.—Voglino describes a disease of the cultivated varieties of chrysanthemum, in which the leaves, more especially towards the margin, are of a thicker consistency than normal, and of an intense black or blackish-purple colour. This appears on the lowermost leaves first, and gradually ascends until all the leaves are attacked. In other instances the disease appears under the form of well-defined circular, ochraceous brown spots, somewhat shining, and bordered with black. Minute black points, the fruit of the fungus, appear scattered over the surface of the leaf. The injury is caused by *Septoria chrysanthemi* (Cav.) and its pycnidial form, named *Phoma chrysanthemi* (Voglino).

Septoria form. Perithecia completely immersed, globose; conidia hyaline, almost filiform, 6-10-septate at maturity, $60\text{-}75 \times 2\text{-}2{\cdot}5\ \mu$.

Phoma form. Perithecia subglobose, black, almost superficial, minute; conidia hyaline, elliptic-oblong, $7\text{-}10 \times 3\text{-}4\ \mu$. 2-guttulate.

Voglino, P., *Malpighia*, 15, p. 329 (1901).

Pear leaf spot, caused by *Septoria piricola* (Desm.), is a common disease throughout Europe and the United States, and in all probability occurs wherever the pear is cultivated. It appears under the form of small, somewhat angular, greyish spots on the leaves, on which the minute black spore-cases can be seen by the aid of a magnifying-glass. When the spots are numerous the leaves turn yellow, and fall quite early in the season. The fruit is not attacked.

The minute perithecia are embedded in the substance of the leaf, a small open mouth piercing the epidermis, through which the spores escape in the form of a long, dark coloured, viscid tendril. Spores hyaline, long, almost filiform, one end slightly thickened, often slightly curved, usually 2-septate, $60 \times 3{\cdot}5\ \mu$. Tubeuf says this fungus is probably a stage of *Sphaerella lucillae* (Sacc.); however, no direct experiment has proved this statement to be correct.

Nursery stock more especially often suffers severely from this disease. Duggar, who has devoted considerable attention to the subject, states that three sprayings with Bordeaux mixture give almost perfect protection. The first immediately after the petals fall, and two subsequent sprayings at intervals of two or three weeks.

Duggar, B. M., *Cornell Univ. Agric. Exp. St., U.S.A., Bull.* 145 (1898).

Strawberry leaf blight (*Septoria fragariae*, Desm.) often causes considerable injury to the foliage of cultivated strawberries; it also occurs on wild species of *Fragaria* and *Potentilla*. The fungus forms rather large, circular, brownish patches with a red margin. At a later stage the central portion becomes pale coloured, and is studded with numerous minute perithecia, out of which the spores ooze in whitish tendrils. Spores elliptic-oblong, 3-septate, hyaline.

Saccardo gives this fungus as a form of *Sphaerella fragariae* (Tul.).

Treatment same as for strawberry leaf spot, which see.

Wheat blight.—During a cold, backward spring the leaves of autumn-sown wheat are often more or less covered with patches caused by *Septoria tritici* (Desm.). Such leaves turn yellow and die prematurely. According to Cavara this fungus causes serious injury to the wheat crop in the north of Italy. It also occurs on other cereals.

The conceptacles are very minute and immersed in the leaf, and form very minute black dots at the surface, due to the mouths of the conceptacles protruding through the epidermis. Conidia filiform, hyaline, 3-5-septate, $50\text{-}60 \times 3\text{-}5\ \mu$.

Janczewski considers that certain other very minute conceptacles, containing myriads of exceedingly minute, slender, curved, hyaline spermatia, which are often found accompanying *S. tritici*, to belong to that species. These minute bodies he has called *Phoma secalinum*.

Very frequently an ascigerous fungus, called *Leptosphaeria tritici*, is found mixed with *Septoria tritici* on the leaves of wheat. The perithecium is black, subglobose, with a conspicuous neck, which usually protrudes through a stoma. The asci are subcylindrical, 8-spored, spores 2-seriate in the ascus, elliptic-oblong, ends narrowed, 3-septate, yellowish.

Care must be taken not to mistake *Septorium tritici* (Desm.) with *Septoria graminum* (Desm.).

Cavara, *Zeitschr. Pflanzenkr.*, 3, p. 16 (1893).
Janczewski, *Recherches sur le Cladosporium herbarum*, etc., Cracow (1896).
Prillieux, *Malad. des Plantes Agric.*, 2, p. 301 (1897).

Wheat node fungus (*Septoria nodosum*, Berks.) attacks the nodes of wheat stems when the plant is about half grown, and forms pale fawn-coloured patches, often bounded by a darker line, and studded with the minute blackish perithecia, spores minute.

This parasite was first observed by Berkeley in 1845, who states that it was very abundant in wheat fields, and did a certain amount of injury. It has not been observed during recent years.

Celery and parsley leaf scorch.—This disease, caused by *Septoria petroselini* (Desmaz.), is often the cause of serious loss unless promptly checked, as when it once appears, it spreads along the rows of celery with great rapidity. It usually appears when the celery is nearly ready for the market. Small, scattered brown patches first appear on the living leaves, these gradually increase in size until the entire leaf is covered; at this stage it turns brown and dies. If the brown spots are examined with a pocket-lens, numerous minute, jet-black spots are seen scattered over their surface. These black spots are the fruits or perithecia of the fungus containing the spores.

Perithecia more or less flattened, with a minute pore, 180-250 μ. Spores filiform, often slightly curved, usually 3-septate, $50\text{-}65 \times 1{\cdot}5\ \mu$.

If detected early in the season, spray with dilute Bordeaux mixture, or with potassium sulphide solution. Diseased foliage should be buried. This disease, as the specific name denotes, also attacks parsley.

Black currant leaf spot (*Septoria ribis*, Desm.) forms small brown then purplish spots on living leaves of the black-currant. Conidia long and very narrow, hyaline, 50 μ long.

Horse-chestnut leaf spot (*Septoria hippocastani*, B. and Br.) forms spots, at first minute and scattered, afterwards

running into each other, and forming large brownish patches on living leaves of the horse-chestnut. Spores rod-like, curved, septate, 55-60 × 3 μ.

Septoria graminis (Desm.) has very minute perithecia which are densely crowded, forming long, greyish, nebulous patches on the leaves of cereals. The conidia are about the same length as those of *Septoria tritici* (Desm.), but considerably narrower and slightly thickened at one end; septa not obvious.

DIPLODIA (Fries.)

Perithecia subcarbonaceous, black, typically papillate; conidia elliptical, 1-septate, coloured.

Brown rot of cacao pods (*Diplodia cacaoicola*, P. Henn.) is responsible for a considerable amount of injury to cacao pods in the West Indies. It has also occurred in Africa. When a pod is infected a circular brown patch makes its appearance, which gradually extends all over the pod, and causes complete destruction of the rind and its contents. The time taken in the destruction of a pod varies according to its state of ripeness, but is usually included between six and ten days from the period of infection. The disease usually commences at the point of insertion of the stalk or at the free end of the pod, but may occur at other points, especially if the rind has been injured, or where it comes in contact with a branch. Diseased pods are especially numerous in the vicinity of the 'breaking grounds,' where the beans are extracted by the pickers. The disease soon spreads to the 'beans,' which are speedily destroyed by a greyish mycelium. When the diseased patches on the rind are about an inch in diameter, the small black perithecia commence to appear at the centre of the patch, and soon liberate their brown 1-septate conidia, averaging 20 × 10 μ.

There is no cure nor means of checking the disease when a pod is once infected. It is suggested that pods should not be allowed to get too ripe, as they are most liable to infection at this stage. All husks, shells, etc., should be destroyed, as should also dead cacao-trees and prunings, on which the fungus also occurs.

Howard, *West Indian Bull.*, 2, p. 192 (1901).
Massee, *Kew Bull.*

DILOPHOSPORA (Desm.)

Perithecia crowded, immersed in a crustaceous weft of hyphae or stroma; spores fusiform, septate, hyaline, furnished at each end with several simple or branched, delicate hairs.

Wheat ear fungus (*Dilophospora graminis*, Desm.) sometimes attacks ears of wheat and arrests the development of

FIG. 132.—*Cylindrosporium padi*. 1, spots caused by fungus on a plum leaf; 2, section through a pustule of conidia of same; 3, conidia of *Exosporium tiliae*; 4, conidium of *Sporodesmium brassicae*; 5, *Helminthosporium graminum* on barley leaf; 6, conidia of same; 7, *Actinomena rosae* on rose leaf; 8, single blotch of same, showing perithecia; 9, conidia of same; 10, conidiophores of *Cercospora resedae*; 11, single conidium of same. Figs. 1, 5, and 7 about nat. size; remainder highly mag.

the grain by forming a blackish-brown, crust-like weft, which involves a portion or sometimes the whole of the ear. The inflorescence of various other grasses, as species of *Festuca Triticum*, *Alopecurus*, etc., are also attacked. The inflorescence is sometimes very much contorted, at others times it

remains straight. The fungus also develops on the sheaths of the leaves. Perithecia globose, crowded in the stroma in which they are immersed; spores fusiform, hyaline, slightly curved, 3-septate, with two or three simple or branched spines at each end, $4\text{-}6 \times 0{\cdot}5\text{-}1\ \mu$.

Although a true parasite, this fungus is comparatively rare and cannot be considered as of any economic importance.

ACTINONEMA (Lib.)

Perithecia flattened, without a definite mouth, seated on creeping fascicles of hyphae that radiate from a discoloured patch of the host; conidia 1-septate.

Rose leaf blotch (*Actinonema rosae*, Lib. = *Asteroma rosae*, D. C.) is a very frequent parasite both on cultivated and wild roses, forming purplish blotches on the upper surface of the leaves; fibrils radiate from the centre of the blotches, and very minute black perithecia are attached to the fibres or strands of mycelium.

Perithecia very minute, without a definite mouth, and containing very small 1-septate conidia.

When present in abundance, the leaves fall early in the season, when usually a second lot of leaves and shoots develop, which are killed by frost. Spray with potassium permanganate, and be careful to collect and burn diseased leaves.

DIPLODINA (West.)

Perithecia subcutaneous or erumpent, subglobose, papillate, black, almost or quite glabrous; conidia elliptic-oblong, 1-septate, hyaline.

Spruce shoot disease (*Diplodina parasitica*, Prill. = *Septoria parasitica*, Hartig) has been shown by Hartig to be the cause of considerable injury to the spruce, both in woods and in the nursery. It has also occurred on *Picea Menziesii*, and may probably attack other species. The presence of the fungus is indicated by the leaves near the base of the young shoots, or those in the middle, becoming brown and soon dropping off. This usually happens in May. At first the apex of the shoot remains unchanged in colour, but on lateral branches it droops. Very frequently the disease begins

at the base of the shoot where it is enveloped by the scales of the terminal bud of the previous year. During the summer the fruit of the fungus appears under the form of small black points on the shrunken shoot; they are often to be found at the base of the shoot only, concealed by the bud-scales, or they may be abundant at the withered apex of the shoot.

The conceptacles are black and very minute, resembling tubercles or sclerotia, one or many-celled, the cavities lined with long, slender conidiophores, each bearing a hyaline, fusiform, 1-septate conidium, averaging 13-15 μ long.

Hartig, *Zeitschr. f. Forst. und Jagdw.*, Nov. 22, 1890, p. 668.

Hartig and Somerville, *Diseases of Trees* (Engl. ed.), p. 143 (1894).

Prillieux, *Malad. des Plantes Agric.*, 2, p. 292 (1897).

Sweet chestnut canker.—Young sweet chestnut-trees, also the shoots that spring from stumps of trees that have been cut down, often suffer from a disease that much resembles in general appearance apple canker, caused by *Nectria ditissima*. The disease is best known in the neighbourhood of Limoges, in France, where the chestnut undergrowth, used for binding-hoops, is an industry of importance. The disease, known locally as 'Javart,' appears on the bark of the shoots under the form of elongated, very obvious patches on the bark, beginning almost immediately above the stump, and soon girdles the shoot. Several diseased patches are often present on the first yard of the shoot from the stump. The bark soon loses its normal colour, and presents the appearance of having been severely bruised, and becomes brownish, depressed, then dries up and cracks, and finally falls away in patches, exposing the wood which is also injured. During the autumn the diseased patches of bark are covered with the conceptacles of a minute fungus, *Diplodina castaneae* (Prill. and Del.), which is the cause of the disease.

Perithecia formed under the epidermis, conico-depressed, wall blackish olive, the mouth piercing the epidermis, $300 \times 150\ \mu$, conidia fusiform, 1-septate, not constricted, $6\text{-}7 \times 1\text{-}1{\cdot}5\ \mu$, conidiophores acicular, 10-12 μ long.

Is the American chestnut disease distinct from the present one?

Prillieux and Delacroix, *Bull. Soc. Myc. France*, 9, p. 275 (1893).

Die back of willow shoots (*Diplodina salicina*, Cke. and Mass.) attacks the tips of willow shoots and causes them to die back for a distance of six inches or more. The shoots become brown and the scales of the buds are indurated. The fungus bursts through the bark at numerous points, forming minute cavities with a raised border. The conidia are very numerous, hyaline, elliptic-oblong, 1-septate, smooth, $18\text{-}24 \times 5\text{-}7\ \mu$.

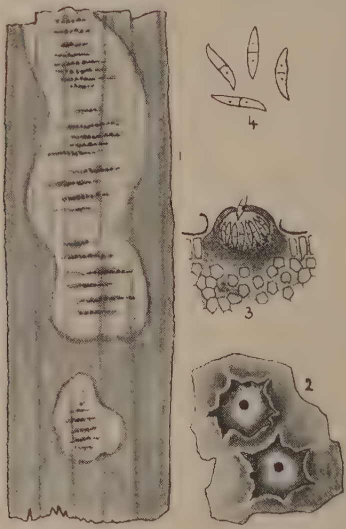

FIG. 133.—*Ascochyta aspidistrae*. 1, on portion of a leaf of *Aspidistra lurida*; 2, perithecia of the fungus bursting through the epidermis of the leaf, mag; 3, section of a perithecium, mag; 4, spores, highly mag.

Diseased portions should be removed and burned.

ASCOCHYTA (Lib.)

Perithecia minute, generally immersed in the substance of bleached spots on leaves or twigs, with a terminal pore; 1-septate, hyaline.

Aspidistra leaf blotch.—Large, irregular, bleached patches are produced on living leaves of *Aspidistra lurida* by *Ascochyta aspidistrae* (Mass.). The perithecia are grouped in blackish streaks which run across the leaf and not along its length. Spores narrowly fusiform, 1-septate, 12-17 × 2-2·5 μ.

Diseased leaves should be removed.

Violet leaf blotch (*Ascochyta violae*, Sacc.) forms large, circular, brown or yellowish patches on living leaves of the sweet violet (*Viola odorata*,) and other cultivated species. Spores cylindrical, 1-septate, 10-11 × 3-4 μ. The dead spots

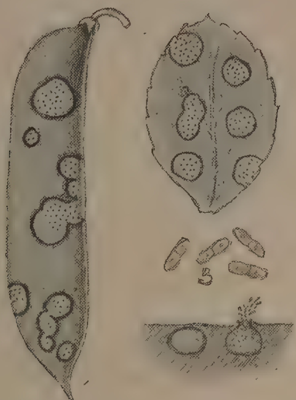

FIG. 134.—*Ascochyta pisi*. 1, pod and leaflet of garden pea attacked by fungus; 2, section through two conceptacles of fungus; 3, conidia. Figs. 2 and 3 mag.

become yellowish-white, dry up, and often fall out. A very destructive disease.

Favoured by excess of moisture. The diseased leaves should be removed on their first appearance, otherwise the disease spreads quickly, the spores being spread by watering or syringing.

Pea spot (*Ascochyta pisi*, Lib.) every now and again appears under the form of an epidemic, attacking cultivated peas, haricot, and French beans, also wild plants belonging to the pea family, as *Vicia*, *Cercis*, etc. It is most frequent on

cultivated peas, forming rather large, irregularly shaped, pale spots, bounded by a dark line, and studded with the minute, dark perithecia. Similar spots are sometimes present on the leaves and stem. The variety known as the 'edible podded' or 'sugar pea' is very susceptible to this disease.

The spores escape from the perithecia as reddish tendrils which soon become pale; spores hyaline, oblong, 1-septate, slightly constricted, $14\text{-}16 \times 4\text{-}6\ \mu$.

Spraying with dilute Bordeaux mixture, on the first appearance of the disease, checks its extension.

Walnut leaf spot.—The living leaves of *Juglans regia* are often disfigured by the appearance of roundish, greyish-brown spots with a darker margin, which vary in size from 1 mm. to 1 cm. in diameter, due to *Ascochyta juglandis* (Boltshauser). These diseased patches become dry and fall away, leaving holes in the leaf. Under a lens minute, lighter points can be seen on the upper surface of the dry patches; these are the mouths or openings of the minute, globose perithecia, which are sunk in the substance of the leaf. The spores are oblong, 1-septate, often constricted at the septum, the two cells are often of unequal size, $10\text{-}13 \times 4\text{-}5\ \mu$.

Boltshauser, H., *Zeitschr. Pflanzenkr.*, 8, p. 263 (1898).

Ascochyta dianthi (Berk.) forms rather large, somewhat circular pale patches, usually bounded by a darker margin, and studded with the numerous, minute, dark perithecia, on living leaves of various species of *Lychnis*, *Dianthus*, and *Saponaria*, both wild and cultivated. Spores narrowly elliptical, or with the widest part above the middle septum, hyaline, $14\text{-}17 \times 4\text{-}5\ \mu$.

The general appearance of the diseased spots resemble those caused by *Heterosporium echinulatum* (Cke.), but a microscopic examination of the fungus at once determines to which of the two the disease is due.

Ascochyta Cookei (Massee) forms blotches on living leaves of *Lychnis vespertina* that are indistinguishable from those caused by *Ascochyta dianthi*, but the spores are cylindrical or with a slight suggestion of being clavate, 1-septate, hyaline, $36\text{-}42 \times 5\ \mu$.

Ascochyta brassicae (Thum.) forms numerous large, usually circular, greyish dull patches on living cabbage leaves; the

centre of the patch is usually darker in colour and brown, the remainder studded with the minute, black perithecia.

Spores fusiform, ends acute, 1-septate, hyaline, $15\text{-}16 \times 3\text{-}4\ \mu$.

This fungus sometimes proves very destructive to cultivated cabbages of various kinds.

Ascochyta armoraciae (Fckl.) forms spots on the leaves of horse-radish. Conidia elliptic, oblong, 1-septate, $18\text{-}20 \times 3\ \mu$.

Ascochyta aquilegiae (Roum.) forms rounded, whitish spots with a dark margin, on columbine leaves. Conidia narrowly elliptical, tinged brown, 1-septate.

MELANCONIACEAE

*** Spores continuous*

MELANCONIUM (Fr.)

Spore-masses produced in the substance of the host, usually in the cortex; conidia elliptical, olive, extruded as blackish, mucilaginous tendrils.

Screw-pine disease.—Specimens of screw-pine (*Pandanus*) grown in this country are not infrequently attacked by a disease which kills the branches, or in some instances the entire plant, as happened at Kew some years ago to a very fine plant. *Melanconium pandani* (Lév.), the cause of this disease, forms black pustules embedded in the bark, from which ooze to the surface black, subgelatinous tendrils, consisting of minute conidia embedded in mucilage. These tendrils are usually produced in such profusion that the branch is completely blackened.

I have been told that mangrove-trees, when growing in their native habitat, are often killed by a disease which gives them a blackened appearance as if they had been scorched. This disease is probably caused by the same *Melanconium*.

An ascigerous fungus, *Nectria pandani* (Tul.), frequently appears on the old and empty *Melanconium* pustules, and the two have been considered as phases of the same fungus. This supposed connection, however, has not been proved, and it is rather outside experience to suppose there can be any relationship.

Fruit erumpent, large, black, conoid, often grouped in

warted, black lines, 1-2 mm. diam., conidia oozing out in black tendrils, elliptic-oblong, pale olive, $5\text{-}9 \times 3\text{-}4\,\mu$; conidiophores long, branched, curved.

If the disease is neglected it spreads rapidly, and the tree soon dies. If diseased parts were cut out on their first appearance, perhaps the disease might be checked, or at all events delayed.

GLOEOSPORIUM (Desm.)

Spore-clusters formed under the epidermis, bursting through at maturity. Spores elongated, continuous, hyaline, borne at the tips of slender sporophores.

Generally on living leaves and stems. The well-known *G. ribis* (Mont.) has been proved by Klebahn to be a conidial form of an ascigerous fungus, *Pseudopeziza ribis* (Kleb.); other forms of *Gloeosporium* have also been associated with higher ascigerous fungi.

The genus *Colletotrichum* only differs from the present in having coloured, spine-like bodies present in the spore-clusters.

Raspberry spot (*Gloeosporium venetum*, Speg.) is the cause of a widespread disease to raspberry canes. The leaves are also sometimes attacked. The injury first appears under the form of small, reddish spots, which gradually increase in size and often encroach on each other, forming irregular blotches, which when old become pale coloured and bounded by a dull red margin. The spore-clusters are minute, clustered, rather prominent; spores almost cylindrical, $7\text{-}8 \times 2{\cdot}3\,\mu$. On raspberry, *Rubus idaeus*, and cloudberry, *R. chamaeomorus*.

When the disease is observed infected canes should at once be cut out, as the spores are formed in great abundance and infect neighbouring canes. Spray with dilute Bordeaux mixture if the plants are not yet in bloom, if they are, use potassium sulphide. When the disease has existed, spray during the winter with sulphate of iron solution.

Peach leaf blotch (*Gloeosporium cydoniae*, Mont.) often causes irregularly shaped brown patches to appear on living leaves of the peach (*Cydonia vulgaris*). As a rule the disease spreads rapidly, all the leaves being attacked, when they wilt and turn yellow and fall prematurely. The spore-clusters are

numerous. The spores are almost cylindrical, $14\text{-}20 \times 2\text{-}2{\cdot}5\ \mu$, and are ejected in slender tendrils mixed with mucus.

Spray with potassium sulphide on the first appearance of the disease. Bordeaux mixture may be used if already prepared for other purposes, but it must be much diluted if the foliage is young, otherwise it will be scorched.

Rhododendron leaf blotch (*Gloeosporium rhododendri*, Briozi and Cavara) sometimes forms large, irregular, yellowish blotches on the leaves of different kinds of *Rhododendron*. The blotches are often zoned, spore-clusters black, shining, grouped in concentric lines; spores cylindric-oblong, $15\text{-}20 \times 4\text{-}5\ \mu$.

The most practical way of arresting the disease is to collect and burn infected leaves.

Grape rot.—This disease, caused by *Gloeosporium ampelophagum* (Sacc.), has proved a veritable scourge in European vineyards, and is much more prevalent on vines grown in the open air than when under glass. It has also caused serious injury to vines in the United States since 1884, and was probably introduced to that country from Europe. In Britain this disease occurs now and again in vineries, but as comparatively few vines are attacked in one locality, its spread is not to be feared if prompt measures are resorted to. The general symptoms of the disease are the presence of numerous blackish spots, which eventually form small wounds at the parts attacked. These spots occur on the leaves, young shoots, tendrils, and fruit. Young green shoots only are attacked. The points of infection are at first minute and brownish; these gradually increase in size and often run into each other, forming large wounds, which eat through the bark into the wood, sometimes extending to the pith, and often form large black chinks, causing the branch to become distorted and rough, and black as if scorched. The tendrils are often similarly affected. On the leaves the spots formed by the fungus are irregular in outline, greyish and bordered by a darker line. Eventually the tissue of the diseased patches becomes dry and dead, and falls away, leaving holes in the leaf. The leaf stalks are often distorted in various ways by the fungus. In many instances the flower stalk is attacked when the flowers are opening, and in such cases the whole inflorescence is killed at once. When the grapes are more or less grown before they are attacked. the diseased

spots are more or less circular, and surrounded by a well-developed, blackish border, hence the American name of bird's-eye rot. When the fungus produces fruit on the diseased spots they are greyish in colour, due to the masses of conidia present. There are generally several diseased

FIG. 135.—*Gloeosporium ampelophagum*. 1, appearance of disease on stem, leaves, and tendrils of vine; 2, diseased grapes; 3, section of pustule of fungus on young grape; 4, conidia. Figs. 1 and 2 natural size; remainder mag.

spots scattered over the fruit. When one grape in a bunch is infected, the disease spreads rapidly until every grape is attacked, the spores being washed by rain from one fruit to another. Diseased fruit often becomes contorted and much cracked, exposing the pips, and finally shrinks and becomes mummified, still remaining hanging on the vine.

Pustules of conidia produced on diseased patches, originating beneath the epidermis through which they push, densely gregarious, originating from a thin stroma, the uppermost cells of which are more or less pointed, and bear the oblong or ellipsoid, hyaline conidia which average $5\text{-}6 \times 3{\cdot}5\ \mu$.

Prillieux recommends a thorough drenching of the vines, before the buds commence to swell, with a solution of sulphate of iron. After expansion of the foliage, dusting with flowers of sulphur, to which a small quantity of powdered quicklime is added, checks the germination of spores. Diseased leaves, fruit, and shoots should be promptly removed. Rich stable manure favours the disease.

Massee, *Gard. Chron.*, Feb. 2 (1895).
Prillieux, *Malad. des Plantes Agric.*, 2 p. 309 (1897).
Viala, *Malad. de la Vigne*, Ed. 3, p. 204.

Lime leaf spot.—Dr. Laubert has recorded a destructive disease attacking species of *Tilia* in Germany. The foliage is the part mostly attacked. Irregularly shaped patches of a yellowish or brownish-yellow colour are present on the leaf, and often run down the two sides of the larger veins, the spots have usually a darker border, and the minute black patches of fungus fruit are developed on the spots on the upper surface of the leaf. Diseased spots also occur on the leaf-stalks and young shoots. The fungus causing this disease is *Gloeosporium tiliaceum* (Allescher) (syn. *G. Tiliae maculicolum*, Allescher). The disease spreads rapidly, and by the end of May the majority of the leaves have fallen and not a green leaf can be seen on the diseased trees. This occurred in the Tiergarten in Berlin and in many other places.

Conidia longish, elliptic-oval, or egg-shaped, hyaline, continuous, often slightly curved, $10\text{-}18 \times 4\text{-}6\ \mu$.

The above differs from a somewhat similar disease of lime-trees in Denmark, caused by *Gloeosporium tiliae* (Oudem.), as described by Rostrup. In the latter the spots on the upper side of the leaf are large, brown, and with a blackish border; on the under surface red-brown, and studded with the fruit of the fungus. Blackish patches also occur on the leaf-stalk and midrib.

It is considered that the parasite winters in diseased shoots, which can be recognised by the presence of sunken, blackish patches. From these spots spores are produced in the spring,

which infect the young leaves and shoots. All such shoots should be removed, and all diseased leaves should be collected and burned.

Laubert, R., *Zeitschr. Pflanzenkr.*, 14, p. 257 (1904).
Rostrup, *Plantepalotogi*, p. 580.

Witches' brooms on paulownia.—A very serious disease attacking *Paulownia tomentosa* (H. Bu.), caused by *Gloeosporium Kawakamii* (Miyake), is recorded from Japan, where the host is now extensively cultivated on account of the excellent wood, which is largely used for cabinet work, musical instruments, wooden clogs, etc. Seedlings and young trees are attacked, the first symptoms appearing on the leaves and young branches. On the upper surface of the leaves light brown spots with a darker margin appear, and the leaf becomes perforated at the diseased points. The principal seat of the disease, however, is young branches and petioles and principal veins of leaves, where the spots are most abundant. First year's seedlings when attacked usually die during the season. From the second year onwards those plants that are not killed outright produce a number of adventitious buds in the axils of the leaves, and these grow into witches' brooms with small, pale green, curled leaves. These brooms are perennial.

The conidia ooze out in roundish, light, salmon-coloured masses, linear, linear-oblong, or linear-clavate, outline somewhat irregular, straight, or slightly curved, hyaline, $10\text{-}13 \times 2{\cdot}5\text{-}3\ \mu$.

Chlamydospores readily produced in water or nutrient media, ovate or elliptical, one-celled, wall smooth, thick, black, $6{\cdot}5\text{-}16 \times 5\text{-}7\ \mu$.

The disease assumes an epidemic character where pure plantations of large extent are formed.

Kawakami, *On the Hexenbesen of Paulownia tomentosa.* Tokio, 1902.

Almond anthracnose.—Dr. Briozi has described an almond disease caused by *Gloeosporium amygdalinum* (Briozi). The green fruit is attacked and its growth arrested. The fungus forms circular spots covered with concentric tufts of fruit. The young shoots are less frequently attacked.

Spores oblong, 2-3-guttulate, $15\text{-}20 \times 4\text{-}5\ \mu$. Sporophores terete, simple, fasciculate, springing from stout mycelium.

At present only recorded from Italy.

Briozi, U., *Zeit. Pflanzenkr.*, 6, p. 65 (1896).

Clover stem rot.—Kirchner describes a stem disease of clover caused by *Gloeosporium caulivorum* (Kirch). The disease appears under the form of long, dark brown streaks or patches on the stem, these become more or less sunken and surrounded by a blackish border, and occur at intervals along the stem; after some time they wilt and the stem falls over.

The pustules are minute. Conidia continuous, hyaline, curved and more or less pointed at the ends, $12\text{-}22 \times 3\text{-}5\ \mu$.

Kirchner, O., *Zeit. Pflanzenkr.*, 12, p. 10 (1902).

Cucumber fruit rot (*Gloeosporium lagenarium*, Pers.) often attacks the leaves, stem, and more especially the tip of the young fruit, which soon becomes soft and rotten.

The pustules are pinkish in colour, and are often disposed in irregular concentric rings. Conidia ovate-oblong, often more or less oblique, hyaline, continuous, $16\text{-}18 \times 5\text{-}6\ \mu$.

Fusarium reticulatum, having 3-septate, curved conidia about $40\ \mu$ long, is constantly met with accompanying the *Gloeosporium*, and some affinity between the two is suspected, but has not been proved.

This is a destructive disease, and is responsible for the death of many cucumbers in the young condition, by causing a soft rot at the tip. All diseased fruit should be removed, and the plant sprayed with dilute Bordeaux mixture at intervals.

Gourd-scab (*Gloeosporium orbiculare*, Berk. = *G. laeticolor*, Berk.) often forms circular spots on nearly ripe vegetable marrows, melons, gourds, and allied fruits.

The conidia escape in viscid tendrils, oblong, ends rounded, hyaline or with a pink tinge, averaging $14 \times 3\text{-}5\ \mu$.

Cabbage leaf spot (*Gloeosporium concentricum*, Grev.) forms roundish, bleached spots on cabbage leaves; in the early stage these spots consist of numerous, minute, white dots arranged more or less concentrically. At a later stage the spots often run into each other, and form large, dead

patches. The leaves of cauliflowers and other varieties of the cabbage family are also attacked.

The conidia escape in the form of viscid, whitish tendrils, and are dispersed by rain, insects, etc. Conidia sausage-shaped, hyaline, continuous, 18-24 × 5-7 μ.

Gloeosporium bicolor (M'Alp.) forms pustules first wax-yellow, then brown, on ripe grapes in Australia. No bitter taste is said to be imparted to the fruit. This species is stated to differ from allies in the conidia being colourless, even in the mass. This is not a very satisfactory discrimination, considering that the conidia of all known species of *Gloeosporium* are colourless.

M'Alpine, *Add. to Fungi on the Vine in Australia*, p. 38.

Gloeosporium theae-sinensis (Miyake) is described as a parasite on tea in the neighbourhood of Tokio. It forms large, reddish-brown, then grey spots on the leaves. Spores hyaline, fusiform or oval, 4-6 × 2 μ.

Miyake, J., *Bot. Mag.* (Japan), 21, p. 43 (1907).

Gloeosporium theae (Zimm.) forms reddish-brown spots on leaves of the tea plant in Africa; spores cylindrical with rounded ends, 14-19 × 4-6 μ.

Gloeosporium pestis (Massee) is destructive to yam leaves in Fiji. It is found that not all varieties are attacked, and the injury is most severe during an exceptionally wet season. The entire upper surface of the leaf is often covered with blackish blotches, resembling *Gloeosporium musae* (Massee) in habit and general appearance, but differing in the smaller spores.

Spots blackish-brown, crowded; conidia ovate-oblong, continuous, hyaline, 18-20 × 5 μ.

Massee, *Kew Bulletin*, 1908, p. 219.

Gloeosporium laeticolor (Berk.) causes depressed, whitish spots, with a dark border, on almost ripe peaches; rosy pustules are grouped in circles on these spots. It has been supposed that the same fungus attacks nearly ripe figs. Conidia extruded in rosy tendrils, elliptic-oblong, 16-17 μ long.

Gloeosporium mezerei (Cke. and Mass.) forms small brown pustules on the upper surface of mezereon leaves. Conidia elliptical or almond-shaped, 15 × 6 μ.

Gloeosporium affine (Sacc.) forms whitish spots on *Hoya* leaves in hothouses. The pustules appear on the spots on the upper surface of the leaves. Conidia cylindric-oblong, $14\text{-}20 \times 4\text{-}6\ \mu$, and ooze out in tendrils.

Gloeosporium cytisi (B. and Br.) form pale spots bounded with red, on laburnum leaves. Conidia oblong, $7\text{-}10 \times 2\text{-}3\ \mu$.

Gloeosporium bidgoodii (Cooke) forms pustules, covered by the blackened epidermis, on the leaves of cultivated species of *Oncidium*. Conidia narrowly elliptical, $18\text{-}20 \times 4\ \mu$.

Gloeosporium pelargonii (Cke. and Mass.). The leaves are attacked on the under surface, but no distinct spots are formed, minute pustules are scattered over the surface, more especially near the veins. Conidia oblong, $20 \times 4\text{-}5\ \mu$. Attacked leaves soon droop and wither.

Gloeosporium cydoniae (Mont.) forms blotches on living quince leaves, causing defoliation.

Conidia cylindrical, slightly curved, hyaline, $15\text{-}20 \times 2\text{-}2{\cdot}5\ \mu$.

COLLETOTRICHUM (CORDA)

Spore-beds innato-erumpent, plane, black, conidia fasciculate, continuous, hyaline; long, blackish bristles are mixed with the conidiophores.

Doubtfully distinct from *Gloeosporium*, the only difference consisting in the presence of sterile bristles in the present genus.

Pod scab of scarlet-runner (*Colletotrichum lindemuthianum*, Briozi and Cavara) causes serious losses at times to growers of scarlet-runners. French beans are also sometimes attacked. The pods suffer most; less frequently the stem and leaves are also infected. On the half-grown pods the disease first appears under the form of small, dark spots bounded by a reddish band; the spots gradually increase in size and encroach on each other, forming irregular patches, which in course of time sink below the general level of the surface. At a later stage the fruit of the fungus appears under the form of minute, black dots on the sunken patches. When the fungus attacks the stem, it usually enters and destroys the tissues to such an extent that the portion above the wound dies.

Pods that are severely attacked are often contorted or twisted, and in such instances the mycelium frequently passes quite through the pod and infects the beans.

FIG. 136.—*Colletotrichum lindemuthianum.* 1, diseased pod of scarlet-runner; 2, section through a pustule of the fungus showing conidiophores bearing conidia at their tips, also two long, sterile spines, which should have been dark in colour, highly mag.

The conidiophores burst through the epidermis in tufts on the diseased spots, cylindrical, simple, 45-55 μ long; conidia apical, oblong, ends rounded, straight or curved, hyaline, $15\text{-}19 \times 3{\cdot}5\text{-}5{\cdot}5$ μ. Spines few in number, or sometimes absent, dark coloured.

Professor Halsted says this fungus is also parasitic on cucumbers, pumpkins, water-melons and musk-melons. If this is correct it may also endanger cucumbers, vegetable marrows, and melons, in this country.

Spraying with Bordeaux mixture early in the season will either check or prevent the appearance of the disease. This cannot be continued after the plants commence to bloom. Diseased pods and leaves should be removed. Seed showing traces of infection should not be sown. A damp situation favours the spread of the fungus.

Halsted, *Bull. Torrey Bot.*, 20, p. 246.

Massee, *Gard. Chron.*, May 7, 1898.

Voglino, *Fungi dannosi alle Piante Coltivate*, pl. 8.

Witches' brooms of cacao.—In 1900 Ritzema Bos announced the presence of a serious disease of the cacao-tree, which appeared under the guise of witches' brooms, which he attributed to a fungus he named *Exoascus theobromae*. I soon afterwards examined specimens of the same disease from Surinam, forwarded by Mr. Hart of Trinidad to Kew, for

investigation, and failed to corroborate the statement that it was due to an *Exoascus*. I only found sterile mycelium, which certainly did not belong to an *Exoascus*. At a later date Dr. Van Hall and A. W. Drost, who were located in the West Indies, and had ample opportunities for investigating the disease in a living condition, have shown that disease is not caused by a species of *Exoascus*, but by a fungus of a totally different nature, on which they have bestowed the name of *Colletotrichum luxificum*. The witches' brooms or hypertrophied branches are, as a rule, recognised by being much thicker than normal branches, the surface is irregular and more or less undulated, and the thickened base marked by longitudinal grooves. The leaves produced on brooms never attain to the normal size, and remain soft and pliant, and are often deeper in colour than the ordinary leaves. Lateral branches are usually present, and as is usually the case, the hypertrophied branches are more or less vertical in growth. The brooms develop very quickly, and are dry and dead within a short space of time. The inflorescence is also attacked, resulting in the crowding together of a great number of flowers, some borne on simple flower-stalks, in others the flower stalks are much branched, and among the flowers vegetative shoots often appear. Very few of these diseased flowers produce ripe fruit, but the product is usually deformed, small, and round in shape. Finally, the fruit is often also attacked by the fungus, causing the disease known as 'blackening,' or 'hardening' of the fruit, which appears under the form of a black patch on the fruit, and causes the tissue of the affected part to become as hard as a stone. At such points the seeds are spoiled, being closely surrounded by the dried-up pulp as if mummified.

The branches are infected when quite young, and the mycelium permeates all the tissues of the branch, and also enters the leaves.

On hardened fruit or on the witches' brooms the fungus forms minute fruiting pustules, dingy white or tinged rose-colour, 0·1-0·3 mm. diam. Black or dark grey, multiseptate and sterile hairs, tapering from base to apex, 50-120 μ long stand erect amongst the conidiophores. Conidia hyaline, oval or ovoid, sometimes slightly narrowed at the middle, $13\text{-}19 \times 4\text{-}5\ \mu$. The conidia are produced in chains.

Diseased trees produce but little fruit, and eventually die. A systematic removal of all diseased portions is recommended.

Hall, Dr. C. J. J. van, and Drost, A. W., *Soc. Bot. Néerlandaise*, 4, p. 243 (1908).
Massee, *Bull. Misc. Inform.*, Trinidad (1901).
Ritzema Bos, *Tijdschr. Plantenzeik.* (1900), p. 65.

Fig anthracnose.—A disease of figs has been observed in Carolina, caused by *Colletotrichum carica* (Stevens and Hall). The fruit is attacked in various stages of growth, and shows large blotches covered with the fruit of the fungus. The leaves are also attacked.

Spore-mass brown, then black; bristles few—sometimes none—slender, brown; conidia elongated, $8 \cdot 5\text{-}20 \times 3 \cdot 5\text{-}6\ \mu$.

Stevens and Hall, *Zeit. Pflanzenkr.*, 19, p. 65 (1909).

Bitter orange spot.—The leaves, twigs, and fruit of the bitter orange or pomelo suffer in Florida from injury caused by *Colletotrichum gloeosporioides* (Hume). Irregular brownish-yellow spots appear on the leaves, and at a later stage these spots on the upper surface of the leaf are marked with black points arranged in concentric circles; these represent the fruit of the fungus. The young twigs are also attacked, the spores probably gaining an entrance through wounds.

Spores cylindrical, hyaline, continuous, $16\text{-}18 \times 4\text{-}6\ \mu$.

Hume, H. H., *Florida Agric. Exp. St.*, *Bull.* No. 74 (1904).

Sisal hemp disease (*Colletotrichum agaves*, Sacc.) causes considerable injury to sisal hemp and cultivated agaves. The older leaves are attacked first, small sunken patches occurring at the points of infection; these points gradually extend. Sisal hemp leaves wither from just under the terminal spine for half their length or more.

Pustules conical, formed under the epidermis on pallid spots; bristles few, brownish-yellow, 2-3-septate, $90\text{-}100 \times 5\text{-}6\ \mu$; conidia straight, hyaline, $22\text{-}26 \times 4\text{-}5\ \mu$.

Cutting off the leaves on the first appearance of the disease is the only practicable means of checking the spread of the fungus.

Hollyhock anthracnose (*Colletotrichum althaeae*, Southw.) causes trouble to hollyhocks grown in greenhouses in the United States. Any part of the plant may be attacked; on the leaves brown spots are formed which may increase in size until the entire leaf is diseased and withered. Spots light yellowish-brown to black.

Conidia flesh-colour in the mass, colourless singly, irregularly oblong, 11-28 × 5 μ.

Spinach anthracnose (*Colletotrichum spinaceae*, Ellis and Hels.) is destructive to spinach in the United States, forming spots on the leaves, which are at first minute and watery in appearance. These gradually increase in size, become grey and dry, and studded with numerous dark points, the fruit of the fungus. The fungus emerges through the stomata.

Conidia falcate or subfusoid, hyaline, ends subacute, 14-20 × 2·5-3 μ.

Halsted, *N. Jersey Agric. Coll. Expt. Sta.*, *Bull.* No. 70.

Colletotrichum oligochaetum (Cav.) attacks the cotyledons, leaves, stem, and fruit of melon, vegetable marrow, cucumbers, and other cucurbitaceous plants. On the stem and leaves ill-defined, yellowish spots appear; on the fruit the disease spreads rapidly, forming yellowish-white blotches which soon cause the fruit to rot. On the dead patches, killed by the parasite, minute, flesh-coloured spots appear; these are the masses of spores. When the plant is young when attacked, it is soon killed; older plants resist longer, but the fruit suffers.

The fruit consists of minute, convex stromata covered with cylindric basidia 10-12 μ long, each bearing a hyaline, cylindric-ovate conidium; the sterile hairs springing from the stroma are few in number, 3-5, blackish-olive, with 1-2 septa.

Cavara, *Rev. Mycol.* (1889), p. 191.
Prillieux and Delacroix, *Bull. Soc. Mycol.*, 10, p. 162.

CYTOSPORINA (Sacc.)

Stroma wart-like, immersed, enclosing an irregular cavity, the walls of which bear the conidia. Conidia filiform, hyaline, continuous, usually curved, escaping through one or more openings under the form of a coloured mucilaginous tendril.

Gooseberry collar rot.—According to Van Hall, *Cytosporina ribis* (P. Magnus) attacks gooseberry bushes at the collar. The cortex is first attacked, the mycelium gradually invading the wood, when gumming takes place, and the supply of water, etc., is cut off from the above-ground portion of the bush, which consequently dies. After the fungus has been

present for some time, numerous small, black stromata are formed in the peripheral portion of the bark. These stromata possess labyrinthiform cavities in their interior, the walls of which are lined with conidiophores bearing filiform, curved, hyaline, continuous conidia, $33 \times 1\text{-}5\ \mu$.

These conidia escape in the form of yellowish, mucilaginous tendrils through one or more mouths or openings in the stroma. This disease must not be confounded with the gooseberry collar rot caused by *Botrytis cinera*, which is much more prevalent in this country. In the latter disease the black bodies present in the bark are true sclerotia; solid, externally black, inside white, and after a period of rest give origin to the conidial *Botrytis* form of fruit.

Hall, C. J. J. van, *Ann. Mycol.*, 1, p. 503 (1903).

CYLINDROSPORIUM (Unger.)

Spore-masses formed under the epidermis, white or pallid, discoid or subeffused; conidia filiform, continuous, hyaline, often flexuous.

Considered as conidial forms of *Entyloma*.

Cherry and plum leaf blight.—The injury caused by *Cylindrosporium padi* (Karst.) is pretty generally distributed in Europe, and of late has become too well known in the United States. The foliage is the part that suffers, and is most prevalent on nursery stock, but older trees are also attacked. About the end of May minute, pale, or reddish spots appear on the leaves; these increase in size, become brown, and eventually the tissue of the diseased patches dry up and fall out, leaving holes in the leaves. When the attack is severe, the leaves fall quite early in the season. In the case of cherries the leaves usually assume autumnal tints before falling, whereas plum leaves fall while yet quite green. Great variability exists as to the susceptibility of different varieties to this disease, the English morello cherry being amongst those that suffer most.

Forming angular, brownish spots on both sides of the leaf, pustules hypophyllus, covered at first by the raised epidermis, conidia filiform, flexuous, hyaline, oozing to the surface, $48\text{-}62 \times 2\ \mu$.

Spray with dilute Bordeaux mixture when the leaves are expanding, and again after an interval of three weeks.

Fairchild, *Journ. Mycol.*, 7, p. 249 (1893).
Pammel, *Iowa Agri. Exp. St.*, *Bull.* 13 (1891).

Chrysanthemum leaf blight (*Cylindrosporium chrysanthemi*, Ellis and Dearness) has proved destructive to cultivated chrysanthemums in Canada, and has been also observed in this country. Large, brownish blotches appear on the leaves, which soon turn yellow and die. When the foliage is attacked the flower-buds do not expand. The diseased leaves do not fall, but hang down round the stem.

Spots large, becoming blackish, pustules of conidia appear on both surfaces of the blotches; conidia fusoid, almost straight, $50\text{-}100 \times 3\text{-}4{\cdot}5\ \mu$.

Diseased plants were sprayed with various solutions without checking the disease. It is recommended to remove and destroy infected plants.

OPHIOCLADIUM (CAVARA)

Forming minute, downy tufts, fertile hyphae fasciculate, much curved; conidia borne singly at the tips of the conidiophores, hyaline, continuous.

Allied to *Oospora*.

Barley mildew.—Cavara has described a new mould parasitic on barley leaves. It forms very small, grey flecks on which are seated minute, fruiting tufts of the fungus, which come through the stomata from a subepidermal stroma. The parasite, called *Ophiocladium hordei* (Cavara) is not injurious up to the present.

Tufts very minute, white, in groups on dead streaks on the leaf. Conidiophores springing from a subepidermal white stroma, hyaline, continuous or 1-2-septate, $20\text{-}30 \times 3\text{-}4\ \mu$; conidia elliptical, hyaline, $6\text{-}8 \times 4\text{-}5\ \mu$.

Cavara, F., *Zeitschr. Pflanzenkr.*, 3, p. 25 (1893).

HYPODERMIUM (LINK.)

Spore-clusters produced under the cuticle and bursting through at maturity, often elongated; spores produced in chains, elongated, continuous, hyaline.

Orchid leaf spot (*Hypodermium orchidearum*, Cke. and Mass.) forms minute, blackish, elongated spots on living leaves of *Cymbidium eburneum*. The spots are arranged in groups, often extending for a distance of one to two inches, and at these points the leaf turns yellow and dies. When the spore-clusters burst through the epidermis they are blackish owing to the dark-coloured fungus mycelium. The spores are hyaline and produced in chains, but soon separate from each other in contact with moisture. They are narrowly elliptic-oblong, and measure $25\text{-}30 \times 5\ \mu$.

Sponging the leaves with a rose-coloured solution of permanganate of potash destroyed the spores, and checked the spread of the disease.

LIBERTELLA (Desm.)

Spore-masses of various form, covered by the epidermis, the conidia usually escaping in a coloured, mucilaginous tendril, slenderly fusiform, elongated, continuous, hyaline.

Fig-tree canker (*Libertella ulcerata*, Mass.) is frequently the cause of very serious injury to fig-trees grown under glass. Soon after a given point of stem or branch is infected the bark shows minute, radiating cracks, which gradually increase in size until eventually a large cankered wound results, the bark and sap-wood being completely eaten away. If the wound is confined to one side of the branch, the latter may continue to live for some time, but if, as is frequently the case, the branch is girdled, the portion above the wound dies almost at once, and soon becomes more or less covered with the fruit of the fungus, which oozes out of the dead bark in the form of very minute hairs or tendrils consisting of myriads of very minute conidia held together by a mucilaginous substance which becomes hard and rigid when dry, but melt and are dispersed by rain or dew.

Pustules gregarious, numerous, minute, developed under the epidermis, which is eventually ruptured, the tendrils of conidia of a pale colour, oozing into the air; conidia fusiform, ends acute, continuous, curved, hyaline, $55\text{-}60 \times 4\ \mu$.

No higher stage has as yet been connected with this conidial form.

No success attended attempts at infection with conidia on an unbroken surface of a branch, whereas infection followed the placing of conidia in minute punctures. A knife that

was used for cutting away a cankered portion was afterwards used, without cleaning, for making an incision in a healthy branch, and infection followed. The conidia germinate freely in the white milky latex, and when cutting away diseased portions, care should be taken not to allow the latex to come in contact with healthy parts. All cut surfaces should be covered with tar at once.

Massee, *Gard. Mag.*, July 23, 1898.

NAEMOSPORA (Pers.)

Spore-bed covered by the epidermis, bright coloured, mucilaginous; conidia hyaline, sausage-shaped, very minute, extruded through a perforation in the epidermis in viscid tendrils.

Die back of peach shoots.—Two-year-old peach shoots frequently die in considerable numbers, and unless removed are very conspicuous during early summer, projecting beyond the green mass of foliage. On such shoots the leaf-buds expand normally in the spring without any suggestion of disease, but just about the time when the blossom is fully expanded the young leaves suddenly wilt, turn brown, and die within a few days. At the same time the petals change to a rusty brown colour and the flowers droop, but remain attached to the branch for some time, as also do the leaves. Finally the shoots bearing wilted leaves and flowers assume a deep claret-red colour, and shrivel more or less as the season advances. During the months of May and June of the following year these dead branches become studded with minute, dull, orange-coloured tendrils oozing out of the wood. The tendrils consist of masses of very minute conidia, about 3×1 μ, embedded in mucilage, and belong to *Naemospora crocea* (Bon.), the cause of the disease.

Only very young shoots can be infected, and probably the conidia are conveyed on the feet of birds from diseased to healthy shoots.

All diseased shoots should be removed before the conidia are formed.

Massee, *Kew Bull.*, 1908, p. 269.

** *Spores 1-many-septate*

PESTALOZZIA (De Not.)

Pustules minute, erumpent; conidia oblong, 2-many-septate, central cells coloured, end ones hyaline, apical cell bearing 1-many hair-like appendages.

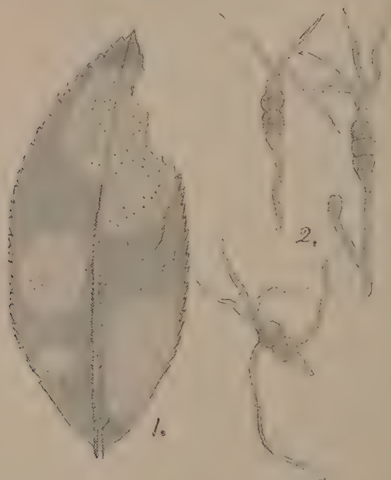

FIG. 137.—*Pestalozzia guepini.* 1, blotches caused by the fungus on a tea leaf; 2, conidia of fungus, highly mag.

Grey blight of tea plant (*Pestalozzia guepini*, Desm.) is said by Sir George Watt to be one of the most destructive and dangerous parasitic fungi that attack the tea plant. It occurs in Assam and Cachar, and probably wherever tea is grown in India and Ceylon. The disease first appears as minute, brownish-grey spots on the upper surface of the leaf; these spots gradually increase in size and often coalesce, forming large, irregular blotches which become grey, and are sprinkled with minute, black points, the fruit of the fungus. During the increase in size the blotches are often bordered with a dark, slightly raised line. Diseased leaves are not at all blistered or swollen, in fact the diseased patches shrink a

little and are thinner than the healthy part of the leaf. The disease is said to start, as a rule, on one side of the bush, and usually on the same side on all the bushes of an affected plot, which suggests the conveyance of spores by wind from some other infected region.

The fungus is also parasitic on species of *Camellia* and *Rhododendron* in India, also in Europe. In the United States it is present on introduced species of *Camellia* and *Citrus*, from whence it probably passed on to the native species of *Magnolia*. It also occurs on indigenous plants, *Niphobolus*, in New Zealand, and on *Alphitonia* in Queensland.

Pustules minute, dot-like, on bleached spots; conidia elliptical, ends narrowed, 3-4-septate, end cells hyaline, central ones coloured, apical cell with 3-4 very slender, hyaline hairs.

If diseased leaves were collected and burned, the disease could be stamped out; the work, however, should be general, and not confined to certain plantations only, as the evidence at hand strongly suggests that the spores are carried by wind, birds, etc., from one place to another. Care should be taken also that the fungus is not allowed to flourish undisturbed in wild plants adjoining tea plantations.

Massee, *Kew Bulletin*, 1898, p. 506.
Watt, *The Pests and Blights of the Tea Plant*.

Conifer seedling disease.—Seedlings of spruce and silver fir are frequently destroyed in large numbers by *Pestalozzia hartigii* (Tubeuf). In summer young plants lose their colour and die. On examination, the cortex just above the ground is found to be killed, and closer search reveals the presence of numerous minute clusters of fungus mycelium or stromata bearing the conidia of the fungus.

Pustules immersed, globose, springing from a flattened stroma; conidia emerging in black masses, at first hyaline, continuous, then 3-septate, ovate-oblong, the two central cells large, coloured, terminal cell small, hyaline, 18-20 μ long, setae 1-4 at apex of conidium.

Remove and burn diseased seedlings.

Hartig and Somerville, *Diseases of Trees*, p. 136.

Pestalozzia lupini (Sor.) is recorded as a pest attacking the cotyledons of cultivated species of *Lupinus*.

Spores 5-6-celled, end cells hyaline, terminal cells with 3-4 slender, hyaline spines; spores $54\text{-}60 \times 16\ \mu$; spines up to $80\ \mu$ long.

Wagner and Sorauer, *Zeitschr. Pflanzenkr.*, 8, p. 266 (1898).

ENTOMOSPORIUM (Lév.)

Perithecia spurious, globose depressed, black, mouthless; conidia of two superposed cells, with two or more cells springing from the median septum, all the cells bearing delicate hairs.

Leaf scald, due to *Entomosporium maculatum* (Lév.), often proves very injurious to pears; it also attacks apple, peach, cherry, quince, and other fruit-trees belonging to the family Rosaceae. I almost invariably find the fungus fruiting first on the shoots of the previous season, where it occurs on small, dingy red, slightly depressed spots. The fact that the disease can frequently be found on the young leaves of buds that are only just unfolding, suggests that the mycelium present in diseased shoots travels into the buds and infects the leaves. On the leaves, most obvious on the upper surface, the disease first appears under the form of a number of small, round, red spots. These spots gradually increase in size and run into each other, forming irregularly shaped blotches, which change to a brownish colour, and show a few projecting black spots, the fruit of the fungus. When the leaves are attacked when quite young they soon turn brown, shrivel, and fall early. When older leaves are attacked they do not shrivel, owing to their rigidity, but soon fall. The fruit is also attacked; the spots are at first red, afterwards becoming brown, and extending their size as on the leaves. The flesh sometimes cracks, as when attacked by pear scab. When spores are placed on a young, living leaf, minute, red spots appear in about five days, and if the weather remains dull and moist, mature spores, capable of infection, are produced at the end of three weeks. On older leaves the whole process of development is slower, and in some instances the disease only forms small red spots which do not produce fruit. I have not succeeded in infecting young cherry leaves with spores obtained from a pear leaf, although some of the same gathering of spores infected other pear leaves.

Sorauer has described an ascigerous fungus he called *Stigmatea mespili*, which occurred on dead leaves along with *Entomosporium*, and which he considers as being the higher form of the last-named fungus. He offers no cultural evidence, however, of this supposed relationship, which thus rests only on juxtaposition of the two.

The black perithecia are flattened and have an imperfectly formed mouth. Spores several-celled, the minute, lateral cells springing from the median septum, very small, lateral, and terminal cells each terminated by a slender hyaline hair, $18\text{-}20 \times 10\text{-}13\ \mu$.

FIG. 138.—*Entomosporium maculatum.* 1, quince leaf diseased; 2, spores of fungus, highly mag.

Spraying with Bordeaux mixture checks the spread of the disease. The dead, diseased leaves should be burned or buried, the diseased shoots should also be cut off. Duggar has the following remarks on this fungus. In the nursery the principal damage is done to seedling pears, and further injury is usually to be attributed to the leaf-spot, *Septoria piricola.* As previously mentioned, the budded stock is much less frequently affected by the leaf blight, *Entomosporium maculatum.* Seedling pears throughout the State, and generally throughout the country, suffer seriously from it. The youngest foliage is first affected, and often the leaves

fall early in the season. Later in the season, the sunken, reddish areas on the tips of the branches indicate the disease on those parts, and Sorauer has shown that in the latter places the disease may readily pass the winter. In this country Fairchild has also corroborated these views. The premature hardening or ripening of the young wood prevents the budding operation; or if budding is not entirely prevented, the early cessation of growth in the formative cambium of the stock renders a perfect union of the woods difficult to secure.

The results of all properly conducted experiments upon nursery stock indicate that Bordeaux mixture as a fungicide is essential to success where this disease prevails.

Duggar, B. M, *Cornell Univ. Agr. Exp. St., U.S.A.*, *Bull.* 145 (1898).

Sorauer, P., *Zeitschr. Pflanzenkr.*, 2, p. 372, pl. 16 (1886).

CORYNEUM (Rees)

Spore-beds discoid or pulvinate, subcutaneous, erumpent, compact, black; conidia oblong or fusoid, 2-many-septate, smoky; basidia filiform.

Gummosis of stone fruit-trees.—Peaches, cherries, apricots, almonds, plums, etc., are often severely injured by a fungus known as *Coryneum beyerinckii* (Oudem.). Quite early in spring, when the leaf buds are just expanding, small red patches appear on the under surface of the leaves. These patches increase in size for some time, and about June little black specks, composing the fruit of the fungus, appear scattered over the red patches. The patches are small and fairly circular in outline, and after the spores have been produced, become dry and drop out of the leaf, leaving a number of circular holes which are usually attributed to the action of the 'shot-hole' fungus (*Cercospora circumscissa*). The fungus also attacks the young shoots and forms more or less elongated spots, below which the tissue is killed to the centre of the shoot. It is considered by some that the gumming of stone fruit-trees is caused by the *Coryneum*, and there certainly is frequently a collection of gum close by the wounds caused by the fungus, but on the other hand gummosis frequently occurs in the absence of *Coryneum*, so that it is probable that

other causes also are capable of causing gummosis. I have shown that in one instance the production of large quantities of gum was due to the presence of *Cladosporium epiphyllum*.

In October Vuillemin noted the presence of pycnidia on the dead patches formed by *Coryneum* on the shoots. To these he gave the name of *Phyllosticta beyerinckii* (= *Phyllosticta persicae*, Sacc.). The same author also observed in the spring months perithecia nestling amongst the pycnidia seated on old *Coryneum* scars on mummified cherries that

FIG. 139.—1, *Coryneum beyerinckii*; 2, *Cycloconium oleaginum* on olive leaf; 3, fungus of same; 4, *Scoletotrichum melophthorum*; 5, *Trichothecium roseum*; 6, *Acremoniella occulta*; 7, *Ophiocladium hordei*; 8, *Meria laricis*; 9, basidia and spores of same. All except Fig. 2 highly mag.

had remained hanging on the tree throughout the winter. These perithecia were considered by Vuillemin as constituting the perfect form of fruit of *Coryneum*, and received the name of *Ascospora beyerinckii* (= *Asterula beyerinckii*, Sacc.).

The relationship of the three forms mentioned above has not been established by means of cultures, but rests on their successive appearance on the same scar. Future research is required to definitely settle this point.

Coryneum form. Crowded, short conidiophores spring from a minute stroma situated under the epidermis. Each

conidiophore bears at its apex a single elliptic-oblong, 1-5-septate, most frequently 3-septate, brown conidium averaging $36 \times 15\ \mu$.

Ascospora stage. Perithecia black, depresso-globose, not papillate, and mouth indistinct or absent, 100-130 μ diam., spores elliptic-fusoid, ends obtuse, continuous, hyaline, 5-6-guttulate, $15 \times 5\text{-}7\ \mu$.

The early spring infection is undoubtedly due to conidia produced on the shoots that were attacked the previous season. All such should be removed. Spray with self-boiled lime and sulphur wash.

Prillieux, *Malad. des Plantes Agric.*, 2, p. 337 (1897).
Vuillemin, *Journ. de Bot.*, 1, p. 315; 2, p. 255 (1888).

PHLEOSPORA (Wallr.)

Perithecia imperfectly developed, often formed from the modified matrix. Spores elongated, 2-many-septate, hyaline.

Septoria is distinguished from the present genus by the presence of a distinct perithecium. Approaching the genus *Septogloeum* in the rudimentary perithecium if indeed distinct. In the last-named genus the perithecial wall, as such, is absent.

Minute fungi growing on leaves.

Hawthorn leaf scorch, caused by *Phleospora oxyacanthae* (Desm.), forming crowded, yellowish spots on hawthorn (*Crataegus oxyacanthae*) leaves; spreads rapidly, giving to the tree or hedge the appearance of having been scorched. The minute, imperfect perithecia are mostly present on the spots on the under surface of the leaf. The hyaline, many-septate spores ooze out of the perithecia in the form of a viscid tendril, and measure $70\text{-}80 \times 5\text{-}7\ \mu$.

The fallen leaves should be collected and burned. Spray with potassium sulphide to arrest the spread of the disease.

Phleospora ulmi (Wallr.) forms small spots on living leaves of the elm. Spores almost cylindrical, becoming 4-septate, $50\text{-}58 \times 5\text{-}6\ \mu$.

Phleospora aceris (Sacc.) causes reddish specks or blotches on living leaves of sycamore and maple. Spores narrowly subclavate, 3-septate, $20\text{-}28 \times 5\ \mu$.

SEPTOGLOEUM (Sacc.)

Spore-masses minute, produced beneath the epidermis, sometimes erumpent, pallid; conidia oblong, 2-many-septate, hyaline.

Resembling *Gloeosporium*, but with septate conidia.

Maple blight.—Hartig states that in the neighbourhood of Munich the branches of *Acer campestre* are often killed off before the young shoots develop in the spring by a fungus called *Septogloeum Hartigianum* (Sacc.). In the middle and lower parts of the crown, more especially, often more than half of the shoots of the previous year are killed. As a rule only young shoots are attacked, infection taking place while the epidermis is still tender. When spores alight on the surface of such shoots, they germinate within a few hours, the germ-tubes piercing the epidermis and gradually extending for a distance of two to four inches, passing along the medullary rays and into the vessels. At a later stage the fungus forms cushion-like masses of fruiting bodies under the epidermis, which becomes ruptured at these points. Shoots that are attacked do not die the same year, and show no external evidence of the disease during the autumn.

Spore-beds erumpent, elongated, gregarious, 1-2 mm. long, greyish-green, bordered by the torn epidermis. The crowded, cylindrical conidiophores spring from a colourless stroma, and each bears at its summit an ovate-oblong, 1-3-septate, most frequently 2-septate subhyaline conidium, $24\text{-}36 \times 10\text{-}12\ \mu$.

Hartig states that infection takes place in May or June, by conidia washed by rain from the higher diseased branches on to the young shoots situated lower down. Dead shoots should be removed from the crown during the winter.

Hartig, *Forstl. Nat. Zeitschr.*, Aug. 1892.

HYPHOMYCETES

* *Spores continuous*

OOSPORA (Wallr.)

Tufts delicate, effused or pulvinate, lax or rather compact, fertile hyphae, short, slender, simple, or sparingly branched; conidia produced in chains, globose or elliptical, hyaline or clear coloured.

American potato scab (*Oospora scabies*, Thaxter) usually attacks potato tubers when young, forming rough patches on the surface known as 'scab.' When just dug up, a very delicate greyish mould is present on the diseased patches, which, however, soon dries up and entirely disappears. Beet, swedes, carrots, and cabbages appear to be also susceptible to the disease, and should not follow a crop of potatoes, as the germs remain in a living condition in the soil for some years.

Vegetative hyphae rarely 1 μ thick, curving irregularly, septate or falsely septate, branching; aerial hyphae at first white, then greyish, evanescent, breaking up into bacteria-like segments after producing spirillum-like 'spores' by the coiling of their free extremities; forming a firm, lichenoid pellicle on nutrient jelly, and usually, when growing in contact with air, producing a deep, black-brown discoloration of the substratum.

I have but rarely observed this disease in this country. Professor Arthur states that steeping potatoes intended for 'seed' in a solution of half a pint of formalin in fifteen gallons of water for two hours is a complete specific. It would be wise, when circumstances permit, to use healthy 'seed' potatoes.

Arthur, *Indiana St. Bull.*, No. 65.
Thaxter, *Ann. Rep. Conn. Agric. Exp. Sta.*, 1890.

Defoliation of conifers.—Professor Oudemans has shown that the defoliation of various conifers, *Abies excelsa*, *A. pinsapo*, *A. nordmanniana*, *A. douglasii*, etc., is brought about by a very minute and inconspicuous fungus which he has named *Oospora abietum*. A single row of very minute, greenish-grey, fluffy tufts emerge through the stomata on each side of the median vein on both sides of the leaf. The mycelium present in the tissues of the leaf rob it of food, and thus bring about its premature fall.

Tufts minute, emerging from the stomata; conidiophores short, unbranched; conidia elliptical, ends rounded, continuous, $10\text{-}12 \times 6\text{-}7\ \mu$.

It is recommended that fallen leaves should be collected and burned. This is, I am afraid, an unpractical method.

Oudemans, *Comp. Rend. Acad. Roy. Sci. des Pays-Bas, séance de jan.*, 1897.

SPOROTRICHUM (Link.)

Hyphae vaguely and repeatedly branched, with or without septa, all similar and procumbent; conidia springing from the tips of the branchlets or spinous processes, subsolitary, elliptical or subglobose, continuous.

Differs from *Botrytis* in being procumbent, and from *Trichosporium* in never being black.

Carnation bud rot.—A disease of the flower-buds of carnations in the United States is described by Stewart and Hodgkiss. Diseased buds resemble healthy buds partially opened, but the interior is brown, decayed, and generally moulded, and are sometimes deformed. The injury is caused by *Sporotrichum anthophilum* (Peck), which is always accompanied by a mite, *Pediculopsis graminum* (Ract.). What relation, if any, exists between the fungus and the mite has not been determined, but infections made with the fungus have produced the disease, whereas the introduction of the mite into flower-beds has led to no injury.

Hyphae forming a loose, white, cottony stratum; spores springing from the tips of short, lateral branches, globose or broadly ovate, ·00016-·0003 of an inch.

The authors state that the fungus produces two kinds of spores, some nearly globose and continuous, as described by Peck, others more or less pear-shaped and 1-septate, their fig. 3. The latter, however, obviously belong to the genus *Trichothecium*, and have no relation to the *Sporotrichum*.

Stewart, F. C., and Hodgkiss, H. E., *N. Y. Agric. Expt. Sta., Geneva, N.Y., Technical Bull.* No. 7 (1908).

BOTRYTIS (Mich.)

Sterile hyphae creeping, fertile erect, vaguely branched upwards, branchlets slender, conidia continuous, elliptical, globose or oblong, colourless or tinted, clustered.

For figure of *Botrytis*, see illustration of *Sclerotinia fuckeliana*.

Fig rot.—Figs grown under glass very frequently become diseased when half ripe. The free end of the fruit presents a waterlogged appearance, and finally collapses with a wet rot.

The injury is caused by *Botrytis cinerea*, which eventually covers the decayed fruit. I have observed that under certain conditions that figs, when becoming ripe, emit a small amount of a sweet liquid through the pore at the apex of the 'fruit.' *Botrytis* spores germinate readily in this liquid, the mycelium passing into the soft tissues of the fig and causing the disease. Whether the emission of liquid by the fig is due to excess of nutrition or to excess of water, I have not been able to determine.

Botrytis diospyri (Briozi), a new species, is described as attacking the fruit of *Diospyros kaki*, in Rome. The fungus is characterised by having much branched mycelium running between and through the cells of the pericarp; the conidiophores are snow-white, and form a thick felt on the surface of the host. Small sclerotia, at first yellowish, then black, are also produced. Ascigerous form not known.

Briozi, U., *Ann. della R. F. Staz. di Patol. Veg.*, 1, p. 132 (1901).

Botrytis depraedens (Cooke). This fungus sometimes proves a serious pest to young sycamores. Greyish spots are formed on the leaves, which often run into each other.

Conidiophores simple, flexous, heads of conidia globose and compact. Conidia globose, 12 μ diam.

ACREMONIELLA (Sacc.)

Hyphae creeping or ascending, bearing short, simple conidia-bearing branches here and there; conidia globose or ovoid, continuous, solitary on the conidiophores, coloured.

Cereal mildew.—Cavara mentions a small hyphomycetous fungus that forms brownish-yellow flakes on the haulms of cereals, near to the nodes. No amount of injury is recorded. The fungus is *Acremoniella occulta* (Cavara).

Mycelium forming a loose, white, cobweb-like layer, hyphae scattered, stout, septate, branched, fertile branches erect, with short, lateral branchlets, each bearing a terminal, globose-depressed, opaque, black conidium, $15 \times 9\text{-}12\ \mu$.

Cavara, F., *Zeitschr. Pflanzenkr.*, 3, p. 24 (1893).

PELLICULARIA (Cooke)

Parasitic. Hyphae creeping, branched, septate, interwoven to form a subgelatinous film; conidia sessile on the prostrate hyphae, solitary, hyaline.

Coffee leaf rot.—This disease was first observed on coffee grown in India, where it is called by the natives 'kole-roga,' or black rot. It has since been found on coffee from Venezuela and from Trinidad. It is also said to attack the betel-nut palm in India. The injury is caused by a fungus called *Pellicularia koleroga* (Cooke), which forms a thin, glairy, whitish film on the under surface of living leaves. The film is quite smooth to the naked eye; when moistened it can be removed as a delicate layer resembling gold-beater's skin, and appears to have no organic attachment to the leaf, but simply rests on the surface after the manner of the black fungi that feed on honey-dew, and form a removable, black film on the surface of leaves on which aphides have deposited honey-dew. In India the disease makes its appearance about July, when the leaves of the trees become covered with a slimy, gelatinous matter, turn black, and fall. The berries likewise rot and fall in clusters.

When a portion of the film is examined under the microscope, it is found to consist of a densely interwoven felt of colourless hyphae embedded in a mucilaginous matrix; the spores are $6{\cdot}5$-$7{\cdot}5\ \mu$, hyaline, minutely warted, and apparently attached latterly to the hyphae. It is, however, necessary that the fungus should be again investigated in a living condition, before any clear idea of its structure or affinities can be arrived at.

No remedial measures have been tried, except sulphuring, so far as I am aware. Probably Bordeaux mixture or other solution would be of value, as the fungus is superficial, as in the Erysiphaceae.

Cooke, M. C., *India Office Report on Diseased Leaves of Coffee and other Plants* (1896).

MERIA (Vuill.)

Conidiophores emerging in small tufts through the stomata, springing from a black, sclerotium-like mass formed in the

air-cavity of the stoma; conidiophores septate, producing a single hyaline conidium from each of the three or four upper cells of the conidiophore.

The conidiophores with their conidia exactly resemble the basidia of the Hemibasidiosmycetes.

Defoliation of larches (*Meria caricis*, Vuill. =*Hartigiella laricis*, Syd.; *Allescheria laricis*, R. Hartig) is sometimes the cause of premature falling of the needles, which is injurious to nursery stock. The fungus appears as minute white specks of mould, issuing from the stomata on the under surface of the leaves; at a later stage it occurs on both surfaces. The affinities of the fungus are uncertain. The terminal branchlets producing the conidia are 2-5-septate, and each cell produces a single spore or conidium, which is exactly the structure of the basidia in the Hemibasidiomycetes, *Auricularia*, etc. Lindau places the fungus in the Hyphomycetaceae. This position is considered as untenable by Vuillemin, who points out that the conidiophores do not spring directly from the vegetative mycelium, but from a pseudoparenchymatous mass of tissue occupying the air cavity below a stoma, which may represent the primordium of some ascomycetous fungus, arrested in its development. The conidia are hyaline, continuous, cylindrical, and slightly narrowed at the centre.

Hartig, *Zentr. f. d. ges. Forstwesen*, 1889.
Lindau, *Engl.-Prantl. Nat. Pflanzen.*, 'Pilze,' Nachtr. 1900, p. 558.
Lindau, *Rabenh. Kr.-Fl.*, Erster Band, 8 Abteil., 'Pilze,' p. 260 (1905).
Vuillemin, *Ann. Mycol.*, 3, p. 340 (1905).

NECATOR (MASSEE)

Spore-bed or sporodochium erumpent, small, slightly convex, becoming orange-red; conidia oblong or elliptic, catenulate, continuous, the chains breaking up, contents of conidia orange coloured.

A remarkable genus, without any near affinities. Probably a phase of some higher form.

Coffee-twig disease.—This disease, caused by *Necator*

decretus (Massee), was sent to Kew from Singapore by Dr. Ridley, who described it as being destructive to coffee-trees, beginning at the tips of shoots and extending backwards, a very unusual mode of parasitism. It bursts through the epidermis as minute, rounded, white pustules, which soon increase somewhat in size, and change to an orange-red colour and a gelatinous consistency.

Spore-beds more or less circular, slightly convex, white, then orange-red, erumpent, gelatinous, covered with conidia agglutinated together; conidia elliptic-oblong, continuous, catenulate, $14\text{-}18 \times 7\text{-}8\ \mu$.

Removing the shoots on the first appearance of the white spots checks the disease. As the conidia are massed together by a gelatinous substance, they are probably washed from one twig to another by rain, or carried from one tree to another on the feet of birds, etc.

Massee, *Kew Bulletin*, 1898, p. 19.

PENICILLIUM (LINK.)

Mycelium creeping, septate; fertile branches erect with branchlets arranged in irregular verticils near the apex; conidia produced in chains, hyaline or clear coloured.

Distinguished by the branchlets of the conidiophores being grouped in irregular whorls or in a penicillate manner, and the long chains of globose or elliptical conidia.

Orange rot.—Samples of rotten oranges received from Natal, Cape of Good Hope, etc., are from time to time sent to Kew for investigation. Some of the specimens are completely rotten on arrival, others more or less so, while some only show a very soft patch without any trace of mildew. In every instance the injury is found to be due to *Penicillium italicum* (Wehmer), which acts as a wound-parasite. In all probability the fungus is present in abundance on decaying fruit in the orange groves, and in those places where the fruit is packed, hence the conidia will be present everywhere, and attacks those portions of the rind that have been in anyway bruised or injured. Repeated experiments conducted at Kew prove that the conidia cannot infect the uninjured surface of the rind, but if the smallest bruise is made, one just sufficient to liberate the contents of a few of the large oil cavities in the rind, infection quickly follows. In about a week a

patch of greater or lesser extent becomes very soft; soon afterwards the greenish coating of mould appears at the surface, and eventually the entire fruit is reduced to a semi-liquid mass. When a case of oranges is opened on arrival in England, absolutely rotten examples are found in close juxtaposition to perfectly sound fruit, proving that unless the skin is bruised infection does not take place, although the sound fruit is completely surrounded by a decaying mass teeming with conidia and mycelium, owing to the wrapping paper having been destroyed.

The fungus is almost indistinguishable from *Penicillium glaucum* in general appearance, just a little greener in tint; it is, however, at once distinguished by the elliptic-oblong conidia, which vary in size, averaging $7\text{-}9 \times 4\ \mu$.

The remedy consists in exercising greater care in gathering the fruit, so as to avoid bruising, and not to pack injured fruit. All decaying fruit should be removed from the plantations, and from the neighbourhood where the fruit is packed.

Penicillium glaucum (Link.) often becomes an injurious parasite on nearly ripe fruit, and on foliage, etc., that has been in any way injured, or from which a sugary sap escapes.

This mainly arises from the presence of the fungus on decaying vegetable matter in the vicinity, fallen fruit, etc. Care should be exercised in removing all such sources of infection, as in nearly all instances spraying is impracticable when fruit is nearly ripe.

Mycelium effused, creeping, white, sterile hyphae creeping, septate, interwoven; conidiophores erect, apex penicillately branched, branches single or in pairs, erect, once or twice forked at the apex. Conidia produced in chains, globose or broadly elliptical, smooth, hyaline, with a tinge of green, $4\ \mu$ diam. The chains of conidia spring from the tips of the ultimate branchlets.

GLIOCLADIUM (Corda)

Conidiophores erect, septate, penicillate above, branches and branchlets septate, crowned by a common mucilaginous head. Conidia acrogenous, irregularly massed together, simple, surrounded by a gelatinous coat.

Differs from *Penicillium* in the conidia not being produced in chains, and in being involved in a mass of mucous forming a glairy head.

Some of the species are considered as representing the conidial condition of the genus *Hypomyces*, the species of which are parasitic on fungi.

Mushroom mould (*Gliocladium agaricinum*, Cooke and Massee) is a fungus which often attacks cultivated mushrooms, causing the cap or pileus to break up into large scales and arresting growth. The fungus forms whitish tufts that are at first more or less gelatinous.

The mycelium is branched, prostrate, giving off erect, fertile conidiophores which bear whorls of branchlets, usually arranged in fours, each branchlet bearing a terminal cluster of conidia. Conidia hyaline, subglobose, produced in chains, at first held in a mass by mucilage, 4-6 μ diam.

There is no cure for this disease, which usually spreads rapidly when it once gains a hold; it is generally introduced along with the manure, and the only certain method of preventing a recurrence of the disease is to remove all the infected soil and replace by a fresh lot.

CHAETOSTROMA (Corda)

Spore-bed black, bordered with black, rigid hairs. Conidia ovoid or subfusiform, rarely subglobose, rarely in chains; conidiophores slender.

Volutella also has the spore-bed surrounded by bristles, but it is never black. *Vermicularia* again has black bristles, but a perithecium more or less perfect is present.

Clivia leaf blotch (*Chaetostroma cliviae*, Oud.) forms large yellow blotches of various form on living leaves of *Clivia nobilis*, beginning near the margin and extending inwards. These blotches finally become studded with minute, black spots, which under a pocket-lens are seen to be bounded by a fringe of black hairs; these spots bear the spores of the fungus.

Spore-beds shining black, finally with a central opening, and surrounded by long, black, pointed, wavy hairs; conidia cylindrical, ends rounded, continuous, hyaline, $23\text{-}28 \times 5\text{-}7\ \mu$.

HORMODENDRON (Berk.)

Mycelium very scanty, mostly located in the tissue of the host-plant; conidiophores erect, septate, slightly coloured;

conidia produced in simple or branched chains, globose or elliptical, continuous, coloured.

This genus is in reality only a condition of *Cladosporium epiphyllum*, and is figured as springing from broken conidiophores of *Cladosporium epiphyllum* on p. 472, Fig. 141, of this book. *C. epiphyllum*, again, is only a conidial form of *Sphaerella tulasnei* (Janczewski). Finally, the *Hormodendron* condition is the well-known *Dematium pullulans* of De Bary.

Barley leaf blotch (*Hormodendron hordei*, Bruhne) is the cause of spots and perforations in the leaves of barley, and when present in quantity on both leaves and haulms, stunts the plant and causes a poor yield. It is perhaps the most omnivorous of fungus parasites known. I have found it on many wild and cultivated plants, as hollyhock, cabbages, deadly nightshade, enchanter's nightshade, *Catalpa bignonioides*, etc. etc. It appears under the form of pale green, translucent spots on the leaves, which finally become perforations, and increase in size, often to a considerable extent, and give the impression of having been eaten by a slug or snail. It is scarcely too much to state that 90 per cent. of the perforations with ragged outlines, so frequently met with on otherwise vigorous foliage, are caused by this fungus. If a perforated leaf is placed on damp blotting-paper in a Petri dish, in the course of a day or two numerous fruiting branches of the *Hormodendron* will be found projecting from the edges of the wounds, when examined under a low power of the microscope.

The spores of *Cladosporium herbarum*, on germination, as also the broken and old conidiophores of the same fungus, produce the *Hormodendron* when in contact with moisture. The *Hormodendron* conidia infect living plants, and continue to reproduce the *Hormodendron* form throughout the summer season, causing a continuation of the epidemic, which, when favoured by congenial surroundings, as when the host is a cultivated plant grown in houses, often assumes serious proportions, as in the case of cucumber leaf blotch, which I find to be far more frequently due to *Hormodendron hordei* than to *Cercospora melonis* (Cooke).

As will be gathered from what has been stated above, the cause of all this mischief is only an intermediate condition of some higher form of fungus. The only certainty respecting its origin is that it originates as a *Hormodendron* from the

germ tubes of the conidia of *Claaosporium epiphyllum*, also from fragments of the conidiophores of the same fungus. Much yet remains to be discovered before the complete life-history of this form-species is cleared up. This time I trust is not far distant, as at the present moment it is being investigated by Mr. C. K. Bancroft, in the Jodrell Laboratory, Kew Gardens.

Conidiophores simple or sparingly branched above, pale olive, bearing simple or slightly branched chains of elliptical, smooth, continuous, pale olive conidia, 4-7 × 2·5-4 μ.

The conidia are acropetal in development.

Bruhne, *in Zopf's Beitr.*, Heft 4 (1894).

STYSANUS (Corda)

Stem erect, consisting of a bundle of hyphae; spores almost hyaline, continuous, arranged in chains, the whole forming an elongated or subglobose head terminating the stem.

Brown rot of potatoes (*Stysanus stemonitis*, Corda) is said to be the cause of a brown rot in potatoes that are stored in a damp condition.

Gregarious, erect, stem blackish-brown, head of spores cylindrical, spores almost colourless, lemon-shaped, in chains, 8 × 5 μ.

The fungus is also very common as a saprophyte on dead wood, stems, leaves, etc.

Carruthers, W., *Jour. Roy. Agr. Soc. Eng.*, 68, p. 226 (1907).

** *Spores 1-many-septate.*

TRICHOTHECIUM (Link.)

Sterile hyphae creeping, fertile conidiophores simple, erect; conidia terminal, solitary or 2-3 in number, 1-septate, hyaline or clear coloured.

Pink rot.—The authors call this pest *Cephalosporium roseum* (Corda), but it is obviously *Trichothecium roseum* (Corda), a very common and widely distributed saprophytic mould, occurring on dead and decaying vegetable matter of all kinds, and everywhere. Craig and Hook, two American

pathologists, have shown that the fungus frequently follows scab on apples, caused by *Fusicladium dendriticum*, and produces rotting. The *Trichothecium* acts as a wound-parasite, and cannot infect an apple through the unbroken skin, but appears at those points where the scab fungus has ruptured the skin, usually as a ring of mould surrounding a scab. By degrees the whole of the scab is covered with a white mould, which gradually changes to a pale pink colour. This colour is due to the presence of numerous conidia. At this stage the skin surrounding an infected scab turns brown. This browning extends in all directions, so that the various scab spots merge into each other, covering large areas, or even the entire surface of the apple. As the spots increase in size they become depressed, due partly to the dissolution of the solid parts of the apple by the fungus, partly to the loss of water due to evaporation through the spots. The flesh beneath the diseased patches also turns brown, and is bitter.

Conidiophores hyaline, erect, simple, crowded, springing from a weft of creeping vegetative hyphae; conidia elliptic-oblong, apex rounded, base narrowed, 1-septate, constricted at the septum, springing in small clusters from tip of conidiophore, obliquely attached, hyaline, pale rose-coloured in the mass, $17\text{-}22 \times 7\text{-}10\ \mu$.

It is considered as an attendant on apple scab, and incapable of causing injury as a primary cause. The prevention is obvious — prevent, by means of spraying and pruning diseased shoots, the appearance of apple scab. If there are signs of the presence of pink rot as harvest time approaches, spray the trees and fruit before picking with copper sulphate at the rate of one pound to 250 gallons of water.

Craig, J., and Hook, J. M. van, *Cornell Univ. Agric. Expt. Sta., Bull.* No. 207 (1902).

SCOLECOTRICHUM (Kze. and Schm.)

Hyphae short, somewhat fasciculate, coloured; conidia oblong or ovate, lateral and terminal, 1-septate.

Cucumber and melon rot.—According to Prillieux, when the weather is unfavourable for the growth of cucumbers and melons about the commencement of June, brown spots appear

on the stem, leaves, and young fruit, which gradually increase in size, cause depressions, and corrode and destroy the tissues. On the fruit these blackish blotches resemble a kind of canker which causes the fruit to rot and decay quickly. Young plants are also often killed. *Scolecotrichum melophthorum* (Prill. and Del.) is the cause of this disease.

Conidiophores straight, erect, bearing at the apex 2-4 short chains of 2-3 olive brown conidia, elliptic-oblong, continuous or septate, measuring $10 \times 3\text{-}4\ \mu$, up to $20\text{-}25 \times 5\text{-}6\ \mu$, and then septate.

Prillieux and Delacroix, *Bull. Soc. Mycol.*, 7, p. 218.

Scolecotrichum clavariarum (Sacc.), forming blackish stains on the lower portions of various species of *Clavaria*, as *C. rugosa*, *C. fuliginea*, etc.

Hyphae densely aggregated, simple, short, straight, obtuse, septate, dark coloured; conidia oblong, 1-septate, constricted, pellucid or opaque, cells often unequal, $15\text{-}20 \times 8\ \mu$.

FUSICLADIUM (Bon.)

Hyphae short, straight, sparingly septate, somewhat fasciculate, coloured; conidia ovoid or subclavate, for a long time continuous, then 1-septate, coloured.

Cherry scab.—Ripe cherries are often disfigured by the presence of one or more blackish-olive, minutely velvety blotches caused by *Fusicladium cerasi*, Sacc. (= *Acrosporium cerasi*, Rabenh.). When the fruit is attacked at an early stage its growth is arrested, and it often remains attached to the tree for a long time in a mummified condition. Presumably the fungus also attacks the young shoots and the leaves, but this is not definitely known. From analogy this fungus is the conidial form of a *Venturia*.

Conidia oblong, ends narrowed, tinged olive, 1-septate when quite mature, $20\text{-}25 \times 4\text{-}5\ \mu$.

Treatment same as for apple and pear scab.

CYCLOCONIUM (Cast.)

Mycelium growing in a circinate manner on leaves, fugacious, black; conidia ovate, 1-septate, springing at once from the mycelium, coloured, solitary.

Olive leaf blotch (*Cycloconium oleaginum*, Castag.) forms small, roundish blotches of a greyish or yellowish colour, bordered with dark brown on the leaves of the olive, only visible on the upper surface. The spots appear for the most part in the autumn on the leaves of the year; young leaves are not attacked. The spots grow slowly and are at first altogether black, due to the spores of the fungus, which gradually disappear from the centre as the spot increases in size. The mycelium is almost superficial, it travels along the substance of the upper walls of the epidermal cells, which are very thick, and does not penetrate the parenchyma of the leaf. The mycelium ruptures the cuticle and comes to the surface to produce the spores.

The conidiophores are very short and bear a single spore at the summit, or in some instances 4-5 spores are produced at the apex. The spores are yellowish-green, usually 1-septate, straight or slightly curved, rounded at the base, apex narrowed, $17\text{-}25 \times 11\ \mu$.

It is stated that half strength Bordeaux mixture checks the disease. Trees that were sprayed four times, in July, September, October, and November, retained their leaves intact, whereas unsprayed control trees suffered much from the fungus.

Prillieux, *Malad. des Plantes Agric.*, 2, p. 362 (1897).

Boyer, *Recher. sur les Maladies de l'Olivier*, Le Cycloconium oleaginum. Montpellier, 1891.

CLADOSPORIUM (Link.)

Hyphae branched, coloured; conidia elliptical, typically 1-septate, rarely 2-3-septate, coloured.

Tomato leaf rust.—This disease apparently originated in the new world, where it proves a dangerous enemy to tomatoes, and at the present day it is equally destructive in Europe, more especially when the plants are forced. It is rarely recorded as occurring on plants grown in the open. The foliage is the part most frequently attacked, the injury first appearing under the form of small spots, which gradually increase in size until very frequently the entire under surface of the leaf becomes covered with a dense, short, browish felt. Diseased leaves soon wilt, change to a dark brown colour, and die. Discoloured stripes or patches often appear on the

stem of diseased plants. The young fruit is also sometimes attacked.

The fungus is *Cladosporium fulvum* (Cke.)

The conidiophores are densely crowded, and emerge through the cuticle in clusters. They are usually sparingly branched, septate, and nodulose, bearing a few conidia near the apex, tinged brown; conidia elliptic-oblong, 1-septate, translucent, tawny-brown, $10\text{-}20 \times 4\text{-}6\ \mu$.

Spray with a dilute solution of potassium sulphide, or with

FIG. 140.—*Cladosporium fulvum*. 1, under surface of a diseased leaf; 2, a cluster of conidiophores bearing conidia, highly mag.

half strength Bordeaux mixture. Spraying, however, is of but little use unless commenced at an early stage of the disease. Remove and burn plants that are badly diseased, as the spores diffuse quickly, and an epidemic that cannot be checked is the result of negligence.

Gummosis of Prunus japonica (*Cladosporium epiphyllum*, Fr.) either killed or severely injured a considerable number of examples of the beautiful flowering shrub, *Prunus japonica*, growing in Kew Gardens. The injury was of the nature

FIG. 141.—(*For description see page 473.*)

commonly called 'gumming.' Stout branches are most frequently attacked, the disease first showing under the form of tear-like drops of almost colourless gum oozing from the branches. The drops are solitary or crowded, and rapidly increase in size, eventually forming nodulose lumps varying in size from a marble to that of a walnut. During damp weather the masses are soft and gelatinous, with just sufficient consistency to hold together, whereas in dry weather they shrink considerably and become horny. The small, colourless masses of gum gradually change to grey, then black, as they increase in size, the discoloration being due to an enormous mass of dark-coloured chlamydospores of the *Cladosporium* developed near the periphery of the mass of gum. The primary extrusion of gum is entirely due to the action of the fungus, which acts as a wound-parasite, entering the tissues through small wounds in the bark, broken branches, and more especially where leaf-buds or flower-buds have been broken off by birds. An olive patch of *Cladosporium* first appears at such injured points, and when the mycelium of the fungus has passed into the tissues, gumming begins, and the fungus grows into the gum mass and forms chlamydospores and microsclerotia. The whole mass of gum is eventually dissolved and drips to the ground, carrying the various forms of reproductive bodies of the fungus along with it, where they remain until the following season, when they again infect the plant. Repeated experiments, made by placing *Cladosporium* spores in small wounds, caused the gumming.

Conidiophores in tufts, erect, becoming flaccid, branched, pale olive; conidia abundant, blackish-olive in the mass, continuous or 1-septate, produced in short chains, pale olive, $10\text{-}12 \times 4\text{-}6\ \mu$.

FIG. 141.—*Cladosporium epiphyllum*. 1, *Prunus* branch with two masses of gum; 2, *Cladosporium* form of fruit; 3, section of periphery of a gum-mass, showing hyphae and chlamydospores of the fungus; 4, dark-coloured hyphae bearing large chlamydospores, from periphery of gum-mass; 5, chlamydospores germinating in a nutrient solution in the absence of air, and producing yeast-like cells which reproduce themselves by gemmation; 6, stray cells emitting germ-tubes, from preceding culture; 7, microsclerotia germinating under same conditions as No. 5; 8, chlamydospores germinating in air, and producing the form known as *Dematium pullulans*; 9, conidia of *Dematium* increasing by budding; 10, fragments of sporophores of *Cladosporium* producing a slender form of *Dematium pullulans* or *Hormodendron*; 11, a *Macrosporium* often present on old canker spots caused by the *Cladosporium*; 12, *Macrosporium* spore germinating. No genetic connection between the *Macrosporium* and the *Cladosporium* could be established. Fig. 1 reduced; remainder highly mag. (From *Kew Bulletin*.)

Collar pruning, along with removal of surface soil and fresh soil added, with a layer of quicklime on the surface, checked the disease.

Massee, *Kew Bulletin*, 1899, p. 1.

Lemon and orange scab (*Cladosporium citri*, Mass.) proves very injurious to orange and lemon trees in Florida and Louisiana. The disease is indicated by the presence of numerous small warts on the leaves and fruit. When the fruit is attacked quite young the warts are often numerous, and measure up to $\frac{1}{4}$ in. high and across, although often smaller. The warts become covered with a delicate mould, grey at first, then dusky, finally black. Trees growing in low, moist situations are most subject to scab, in fact the development and spread of the fungus requires the almost constant presence of moisture in the air. The sour orange (*Citrus bigardia*) is especially susceptible to the disease.

Sporophores tufted, erect, branched, septate, brown, $30\text{-}75 \times 2\text{-}4\ \mu$; conidia fusiform, dusky, usually continuous, occasionally 1-3 septate, $8\text{-}9 \times 2{\cdot}5\text{-}4\ \mu$.

Spraying with ammoniacal solution of copper carbonate is effectual, and should begin when the fruit is just set, and continued at intervals. Bordeaux mixture injures the leaves and fruit. Sour orange-trees should be cut down.

Lamson-Scribner, *Bull. Torrey Bot. Club*, 13, p. 181.
Massee, *Text Book of Plant Diseases*, p. 310.
Swingle and Webber, *U.S. Dept. Agri.*, *Bull.* No. 8.

Plum scab (*Cladosporium carpophilum*, Thüm.) causes a disease of plums, cherries, and almonds, known as 'scab' in the United States. On half-grown fruit the fungus forms greyish or olive-brown spots, which extend radially; when numerous the fruit shrivels and often cracks.

Spots orbicular, often confluent, blackish-green, forming circles; conidia ovate, ends obtuse, continuous or rarely 1-septate, $10\text{-}12 \times 4\text{-}6\ \mu$.

Bordeaux mixture has been suggested; it should contain a little treacle or soap. Spraying should cease when the fruit begins to ripen.

Pammel, *Journ. Agric. Coll. Expt. Sta.*, *Bull.* No. 23.

Pea leaf blotch.—Lasnier points out that seedling peas are

sometimes destroyed by *Cladosporium herbarum* (Link.). Cugini and Macchiati had previously described a similar disease attacking peas, and attributed it to a new species they called *Cladosporium pisi*. As this species did not appear to differ from *C. herbarum*, Lasnier prepared a pure culture of the latter, and infected peas with the spores obtained. The symptoms produced brown blotches sharply defined, and bearing the *Cladosporium* on the leaves and stem, were identical with those described by Cugini and Macchiati. The diseased plants were small and deformed.

Lasnier, *Bull. Soc. Myc. France*, 20, p. 236 (1904).
Cugini and Macchiati, *Bull. St. Agrar. Modena*, 1891, p. 104.

Orchid leaf stain.—A peculiar disease on living leaves of *Oncidium crispum*, resembling an olive-green stain, is caused by *Cladosporium orchidis* (Cke. and Mass.). The olive-green sporophores of the fungus emerge in tufts through the stomata, and bear at the apex and laterally the pale olive elliptical spores which become 1-septate at maturity, and measure about $9\text{-}12 \times 3\text{-}4\ \mu$. Some spores exceed these measurements, others are smaller. The sporophores spring from a compact mass of hyphae formed in the air-cavity below the stoma. The spores germinate freely in water, but failed to infect the leaves of *Cattleya* and other genera of orchids.

Sponging with a solution of permanganate of potash checked the disease.

Cucumber and tomato black scab (*Cladosporium scabies*, Cooke) forms dark, depressed spots on cucumber fruit, which gradually extend and form black, convex wart-like structures which often become cracked, exposing the white flesh. These warts vary in size from half an inch to two inches across. When the spores are mature they give a powdery or minutely velvety appearance to the scabs. The same fungus also causes scabbed, black patches on tomato fruit. When the fruit is young when infected it rarely develops normally, and is in most instances stunted and rendered useless.

Conidiophores rather long and slender, not constricted or nodulose as is usual in *Cladosporium*. Conidia very variable in size, the smaller ones continuous, the larger ones usually 1-septate, very pale in colour, $10\text{-}25 \times 8\text{-}12\ \mu$.

Diseased fruit should be removed, and the plants sprayed at intervals with sulphide of potassium.

Cooke, M. C., *Journ. Roy. Hort. Soc.*, 1904, p. 159.

Cladosporium elegans (Penzig.) forms minute, blackish tufts on dry, bleached spots on living orange leaves in Italy.

Conidiophores wavy, septate, brown; conidia continuous or 1-septate, elliptic-oblong, granulated, pale brown, $18\text{-}20 \times 5\text{-}6\ \mu$.

BRACHYSPORIUM (Sacc.)

Hyphae rigid, almost simple, coloured; conidia ovoid or piriform, coloured, 2-5 septate.

Often growing on wood. A very doubtful genus.

Seedling pea blight (*Brachysporium pisi*, Oudem.) sometimes destroys young pea plants (*Pisum sativum*). Blackish, mouldy patches appear on the leaves, which become yellow, and soon die.

Tufts effused, delicate, blackish, conidiophores smoky, solitary or clustered at the base, septate, smooth or somewhat torulose near the septa, $100\text{-}250 \times 5\text{-}6\ \mu$; conidia solitary, elliptical, 3-septate at maturity, constricted at the septa, smoky, $28\text{-}30 \times 11\text{-}12\ \mu$, epispore densely echinulate under a high power.

This appears to be a species of *Heterosporium* in reality.

Oudemans, *Nederl. Bot. Ven.*, 1898, p. 527.

RAMULARIA (Unger)

Parasitic. Hyphae simple or with short, scattered branchlets, the tips of which are furnished with minute, projecting points, bearing the 1-many-septate, colourless or brightly coloured conidia, which are sometimes produced in chains.

Only differs from *Ovularia* in the septate conidia.

Cacao seed disease.—A batch of cacao seeds received at Kew from Jamaica showed a disease soon after germination, the cotyledons becoming covered with a dense white mould, which eventually killed the seedlings. The fungus is a true parasite, and has been named *Ramularia necator* (Massee). As two distinct batches of cacao, received at different times

from the West Indies, have now shown this disease, it is probably present in some abundance. Externally the infected seeds show no sign of injury, but after being soaked in water for twenty-four hours a white mould is observed when the skin is removed. Mycelium white, filamentous, septate, hyaline, 7-10 μ thick; conidiophores ascending, sparingly branched; conidia elliptic-oblong, 3-septate, $25\text{-}28 \times 7\text{-}9\ \mu$.

Massee, *Kew Bulletin*, No. 6 (1907).

Artichoke leaf blotch (*Ramularia cynarae*, Sacc.) often proves very destructive to the artichoke both in Europe and the United States. The leaves become more or less covered with irregularly rounded, greyish blotches, 2-4 mill. in diameter. These spots are often so crowded that they encroach on each other. After a time the surface of the blotches becomes covered with a delicate, whitish mildew, which is the fruit of the fungus. The conidiophores emerge in tufts through the stomata. When this stage is reached the leaves become brown and die. When the leaves are seriously attacked the plant fails to perfect its heads, which are arrested and valueless.

Conidia cylindrical, very variable in length, continuous, 1-septate, rarely 2-3-septate, $40 \times 4\ \mu$; conidiophores very slender, some very short, others long and branched.

The only remedy is to remove and destroy plants on the first appearance of the disease.

Prillieux, *Malad. des Plantes Agric.*, 2, p. 353 (1897).

Sainfoin leaf spot (*Ramularia onobrychidis*, Prill. and Del.) forms clear, fawn-coloured spots with a darker margin on leaves of *Onobrychis sativa*.

Forming very minute, white, pruinose tufts; conidiophores simple, septate, about $30 \times 3\ \mu$, bearing at the apex a short chain of conidia, elliptic-oblong, 2-3-septate at maturity, $15\text{-}30 \times 4\text{-}5{\cdot}5\ \mu$.

Ascochyta orobi (Sacc.) often accompanies the *Ramularia* on the spots, and it is considered that probably the two are stages of the same fungus.

Perithecia lenticular, brownish-fawn colour, 120-150 μ diam., spores hyaline, 1-septate, $16 \times 5\text{-}6\ \mu$.

Prillieux and Delacroix, *Bull. Soc. Myc. France*, 9, p. 272 (1893).

SPONDYLOCLADIUM (MARTIUS)

Vegetative hyphae creeping, septate, fertile erect, simple, rather rigid, coloured; conidia fusoid, 2-many-septate, coloured, in superposed whorls.

Dry scab of potatoes.—This disease is due to *Spondylocladium atrovirens* (Harz.). It causes disfigurement of the surface of the tubers, followed by a dry rot. Its presence is usually indicated by the occurrence of blackish-olive or blackish-violet patches, which soon become depressed below the general surface of the tuber, due to the breaking up of the tissue. Very frequently only one or two such sunken areas, which vary in size from half to three-quarters of an inch across, are present on a tuber. In other cases there is a thickish layer of dingy olive mycelium present everywhere just under the skin, and the surface of the potato is more or less covered with very small warts. As a rule, numbers of very minute, black sclerotia are formed in the epidermal cells or on the surface, in the neighbourhood of the diseased areas, or in some instances, minute sclerotia are alone present. During a certain period in the development of the disease, the patches are covered with the fruit of the fungus, which under a pocket-lens appears under the form of numerous, very minute, upright, black bristles. As the mycelium permeates the tuber, the tissue becomes dry and somewhat powdery, and breaks away in patches. Those portions of the skin bearing sclerotia also break away in flakes, which remain in the soil and endanger future crops. The dark-coloured mycelium of the fungus spreads from diseased areas along the epidermal cells of the tuber, and if a portion of such an infected tuber is placed in a damp, warm situation for a few days, a plentiful crop of the fruit of the fungus appears on the surface of the tuber. In like manner, if a portion of skin bearing sclerotia is placed under favourable conditions for growth, similar fruit springs from the sclerotia.

The sclerotia, in the absence of fruit, were described by Frank, under the name *Phellomyces sclerotiophorus*, as an independent fungus. At a later date, Appel and Laubert succeeded in obtaining the fruit of *Spondylocladium atrovirens* (Harz.) from these sclerotia, consequently *Phellomyces sclerotiophorus* disappears as an entity, and as a specific parasite attacking potatoes.

Failure attended all attempts to inoculate roots of carrot, parsnip, and turnip with *Spondylocladium*, and it is just possible that this parasite may be confined to potatoes.

The disease was first reported in this country from Scotland in 1908, and was afterwards met with in England during the same year. It has been reported by Professor Johnson as not uncommon in Ireland. It is also known on the Continent and in the United States.

Conidiophores solitary or clustered, cylindrical, septate,

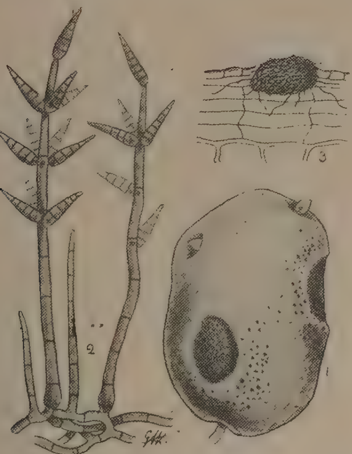

FIG. 142.—*Spondylocladium atrovirens.* 1, potato showing patches of the fungus and micro-sclerotia; 2, fruiting condition of the fungus; 3, micro-sclerotium. 2 and 3 mag.

dingy olive or brownish, up to 400 μ high; conidia elongato-ovate, apex narrowed, 5-7-septate, arranged in whorls, coloured like the stem, $30\text{-}50 \times 6\text{-}9\ \mu$.

Potatoes bearing sclerotia or showing the sunken areas characteristic of the disease, should not be used for sets. Land that has produced a diseased crop should not be again planted with potatoes for some years. Lime or kainit would probably assist in destroying sclerotia present in the land.

Appel and Laubert, *Ber. Deutsch. Bot. Ges.*, 23, p. 218.
Clinton, *State of Conn. Exp. St. Rep.* (1907-8).
Frank, *Ber. Deutsch. Bot. Ges.*, 16, p. 280.
Harz, *Einige Neue Hyphomyceten*, p. 129, pl. 31 (1871).
Johnson, *Econom. Proc. Roy. Soc. Dublin*, 1, p. 161 (1903).
Massee, *Kew Bull.*, Jan. 1909.

EXOSPORIUM (LINK.)

Stroma compact, convex or with the centre depressed; spores elongated, many-septate, coloured.

This genus is closely allied to *Coryneum*, if indeed there is any real difference between the two.

Larch branch fungus (*Exosporium laricinum*, Massee) occurs on living branches of the larch, and although directly of no economic importance, yet indirectly it is sometimes the cause of serious injury, in that the cracking of the bark, and subsequent oozing out of sap and resin, enables the spores of

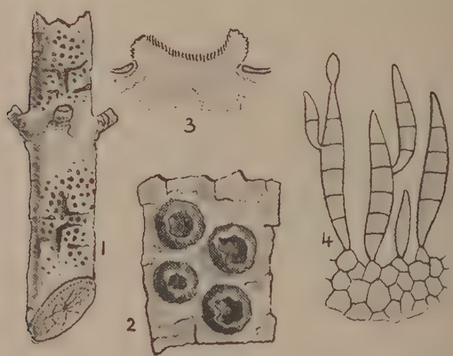

FIG. 143.—*Exosporium laricinum.* 1, fungus on pine bark; 2, fruit of fungus; 3, sections of same; 4, conidia. Figs. 2-4 mag.

the canker fungus (*Dasyscypha*) to gain an entrance into the tissues, and subsequently form a canker wound.

The fungus occurs under the form of minute, black dots in crowded clusters on the bark of young shoots. Stroma more or less circular, often depressed in the centre, and resembling

a minute *Peziza*, black; spores fusiform, ends very acute, 5-7-septate, tinged olive, $25\text{-}30 \times 6\text{-}7\ \mu$.

Massee, *Journn. Bd. Agric.*, Sept. 1902.

Lime-tree bark disease.—The younger branches and shoots of species of *Tilia* are often completely destroyed by *Exosporium tiliae* (Link.). Numerous black pustules burst through the outer bark, which peels off in flakes, exposing the inner fibrous bast in which the black fruiting bodies of the fungus are embedded. The bast soon becomes broken up into shreds, and I have observed sparrows and other birds stripping it off for nest-building. The white decorticated branches remaining on the trees suggest the presence of the parasite.

The black spore-beds are subglobose and 1-2 mm. across, and are covered with large, obovate, brownish, 1-many-septate conidia, $40\text{-}70 \times 14\text{-}18\ \mu$.

The removal of infected branches during the early stage of the disease would check the extension of the parasite.

Exosporium tiliae (Link.), stroma convex, black, minute.

HELMINTHOSPORIUM (Link.)

Conidiophores almost simple, sparsely septate, often nodulose, scattered, or usually tufted, coloured; conidia apical, elongated, 3-many-septate, coloured, epispore smooth.

Maize blight (*Helminthosporium turicum*, Pass. = *H. inconspicuum*, Cooke and Ellis) often injures maize or Indian corn (*Zea mays*), and has been recorded from southern Europe, Queensland, and the United States. Small, pale patches appear on the leaves, and continue to increase in size and run into each other, forming large patches, until finally the greater portion of the leaf is covered, the midrib alone remaining rigid. The spots finally change to a light brown, often surrounded by a darker border, and are at this stage more or less covered with a very delicate, dusky mould. In some cases the blotches become much elongated and do not run into each other. The mycelium spreads in the tissue, which finally becomes dry and brittle. The appearance of the fungus fruit depends on weather conditions. If uninterruptedly warm and moist, the leaves often become brittle and fall to the ground in fragments before the conidia are formed; these, however, are produced at a later stage on the fallen

fragments. On the other hand, if warm weather is suddenly followed by a chill, conidia are produced in abundance. The disease may appear during any period of the growth of the host.

Conidiophores gregarious or subfasciculate on large, dry,

FIG. 144.—*Helminthosporium turcicum*. 1, portion of a maize leaf with fungus; 2, a cluster of conidiophores, two bearing conidia, highly mag.

brownish spots, septate, $150\text{-}180 \times 6\text{-}9\ \mu$; pale olive, apex almost colourless, often nodulose; conidia spindle-shaped, ends acute, 5-8-septate, pale olive, $80\text{-}140 \times 20\text{-}26\ \mu$.

A difficult disease to check, perhaps burning the stubble after corn has been gathered, if practicable, would to a certain extent prevent future infection. Rotation of crops, however, would be the most certain method, and as maize impoverishes the soil to a great extent, this course is advisable.

Bancroft, *Proc. Roy. Soc. Queensland*, 8, p. 108.

Helminthosporium teres (Sacc.) sometimes proves destructive to the barley crop, causing the leaves to shrivel and die. It forms rather large olive blotches on the leaves.

Spots oblong, olive, showing on both surfaces of the leaf; conidiophores fasciculate, often crooked and nodulose, septate, brown, $100\text{-}130 \times 12\ \mu$; conidia acrogenous, straight, cylindrical, ends rounded, 4-5 septate, not constricted, dark olive-brown, $100\text{-}115 \times 14\text{-}18\ \mu$.

Ravn has given a detailed account of this species.

Ravn, Kölpin, *Zeitschr. Pflanzenkr.*, 11, p. 1 (1901).

Helminthosporium avenae (Eidam.) forms numerous narrow, elongated, dry patches on the leaves of oats, and when present in quantity arrests the development of the fruit.

Ravn has dealt in detail with this species.

Closely allied to *H. teres*, but differs in the conidiophores not being fasciculate, but scattered, $150\text{-}200 \times 9\text{-}12\ \mu$, septate, brown; conidia cylindrical, brownish, 4-6 septate, $80\text{-}100 \times 15\text{-}16\ \mu$.

Ravn, Kölpin, *Zeitschr. Pflanzenkr.*, 11, p. 1 (1901).

CERCOSPORA (FRESEN.)

Conidiophores clustered, somewhat flaccid, simple or slightly branched, brownish; conidia worm-shaped, multi-septate, subhyaline or coloured.

Often growing on living leaves, and forming pale, dry spots.

Shot-hole fungus (*Cercospora circumscissa*, Sacc.) attacks the leaves of the peach, apricot, cherry, almond, nectarine, etc., forming small circular patches that bear conidia on one or both surfaces; finally the patches become dry and brown and fall out, leaving holes in the leaf. These holes are usually numerous, and suggest the idea of the leaf having been riddled with small shot, hence the name 'shot-hole fungus.' Such diseased leaves fall early in the season, before the formation of the wood has been completed, or a store of reserve food made by the tree, hence the succeeding crop is a failure. In the case of nursery stock being attacked for two or three consecutive seasons, the trees never thoroughly recover, and, properly speaking, should not be sold. The young branches and also the fruit are attacked at times.

Conidiophores fasciculate, nodulose, brownish; conidia acicular, narrowed towards the apex, tinged brown, $50 \times 3{\cdot}5\text{-}4\ \mu$.

Begin spraying when the leaves are expanding, and repeat at intervals, using self-boiled lime and sulphur compound. Bordeaux mixture cannot be used, as it scorches peach leaves even when much diluted.

Pierce and Galloway, *Journ. Mycol.*, 7, p. 66.

FIG. 145.—*Cercospora circumscissa.* 1, diseased peach leaf; 2, tuft of conidia, highly mag.

Cucumber and melon leaf blotch.—This destructive pest was first observed in 1896, and for the three or four following years it simply ran riot, killing off whole houses of cucumbers within a few days. It was almost entirely confined to the extensive establishments around London, the produce of which mostly found its way to Covent Garden market. At the present day the disease has practically disappeared. This epidemic may in a sense be looked upon as an artificial creation, inasmuch as it can only extend at a rapid rate under the modern conditions of culture, namely, an atmosphere

saturated with moisture, and a temperature ranging between 75 and 90 degrees F. The disease first appeared in a corner of a house, and within four days every plant in the house, which was 100 ft. long, was killed. At this time I visited the house, obtained material, and suggested preventive methods. Within three months of this occurrence, the disease was reported from various other localities, and the season following it was generally distributed in the London district. This rapid extension of the disease was at first inexplicable, until

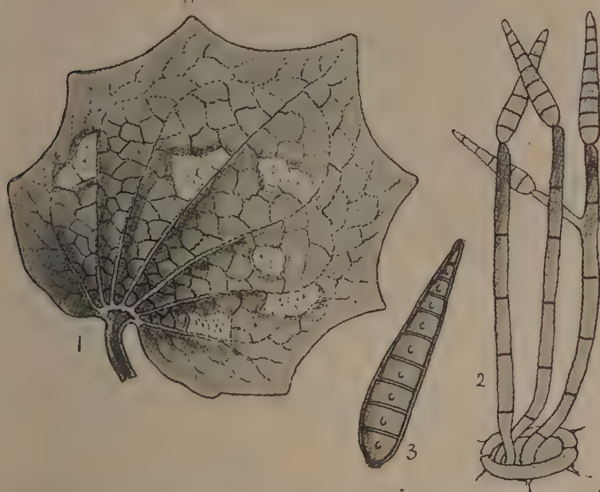

FIG. 146.—1, *Cercospora melonis*, a leaf of cucumber showing early stage of disease; 2, sporophores emerging from a stoma, and bearing spores, mag.; 3, spore, highly mag.

it suddenly appeared in the houses of a grower located at some distance from the nearest known infected area. The explanation was as follows. This grower had sent a consignment of cucumbers to Covent Garden, and by some mistake his own empty packing-cases or 'flats' were not returned, but instead, those belonging to another grower whose plants were diseased. Spores of the fungus had been conveyed from one district to another, adhering to the empty cases. I obtained a case that had contained diseased plants, and

placed it over a young vegetable marrow plant growing under glass, and within three days every leaf was destroyed by the disease.

Minute, pale green, translucent spots first appear on the leaves, which rapidly increase in size and run into each other and turn brown. This may all happen within twenty-four hours. The foliage as a rule is killed so rapidly that the plants become waterlogged and die, due to continued activity of the roots. Conidia appear in numbers when the spots turn brown, and these are distributed by spraying, etc. Conidia that fall to the ground germinate quickly, and form mycelium which soon produces more conidia. The mycelium continues to grow in the soil for at least a year, and produces crop after crop of conidia.

The fungus is *Cercospora melonis* (Cke.).

The conidia are large, cylindrical, and narrowed towards the tip, 7-9 septate, $80 \times 9\ \mu$, supported on dark coloured, long, slender, simple or branched conidiophores.

Soft foliage favours the disease, which does not occur on plants not grown under rushed conditions. Even badly diseased plants, when planted in the open air, produce new leaves and continue healthy. Spraying with sulphide of potassium, if begun as soon as the disease appears, retards its progress. The soil should also be thoroughly well soaked with the solution. Diseased plants should be removed and burned. Care should be taken not to introduce the disease by any of the means cited above. The disease is not carried in the seed.

Massee, *Journ. Board Agric.*, Leaflet No. 76.

Celery and parsnip leaf blight.—Somewhat early in the season, more especially during dull, damp, warm weather, the parasitic fungus known as *Cercospora apii* (Fr.), often causes serious injury to celery and parsnip leaves. The outermost leaves first show the disease under the form of roundish blotches of a sickly green colour at first, gradually changing through brown to grey when old. As the disease progresses the leaves turn yellow and wilt; at this stage the fruit of the fungus, which emerges through the stomata in tufts, is produced, and the spores are washed by rain or conveyed by other agents to other leaves which become infected, and in turn produce a crop of spores. I have

proved by inoculation experiments that when the spores are placed on a young celery leaf, a disease spot becomes evident about the fourth day, and that mature spores are produced in four weeks.

The pale olive sporophores originate from colourless mycelium in the tissue of the leaf, and come to the surface of the leaf in clusters through the stomata of the leaf. Spores

FIG. 147.—*Cercospora apii.* 1, celery leaf attacked by the fungus; 2, fruit of fungus, highly mag.

hyaline, almost cylindrical, a little thickened at one end, 3-10 septate, $50\text{-}80 \times 4\ \mu$.

Spraying with ammoniacal carbonate of copper solution is most efficient in checking the disease, if applied before the disease has advanced too far. The spores on diseased leaves live through the winter, and are capable of infecting a crop the following season, hence the leaves should be gathered and burned. Some portions of leaves, however, are certain to remain on the ground, and rotation of crops, where practicable, would be the safest method. It is stated that when celery is shaded by some means it remains free from disease. This method, however, is only practicable perhaps on a small scale.

Coffee leaf spot (*Cercospora coffeicola*, Berk. and Cooke = *Ramularia Goeldiana*, Sacc.) causes damage to the coffee industry in Brazil, by causing a partial defoliation of the trees. The parasite forms large blotches on the leaves; these blotches begin on the upper side and become greyish and dead in the centre, but are at first dark brown, and finally show on the under side as corresponding, clear brown spots. The fungus also forms spots on young twigs, and on the young fruit, which becomes arrested in its growth. The fruit of the fungus appears as small, black spots on the diseased portions.

Spores elongated, thickened, and rounded at the base, tapering upwards to a sharp point, many septate, almost hyaline, length very variable, averaging $70 \times 5{\cdot}5\ \mu$. Sporophores septate, more or less crooked or kneed, $170\text{-}200 \times 6\ \mu$, springing in dense tufts from a stroma-like mass.

Noack, F., *Zeitschr. Pflanzenkr.*, 11, p. 196 (1901). Several other coffee diseases are noticed in this article.

Potato leaf spot.—Potato leaves attacked by *Cercospora concors* (Sacc.) present somewhat the appearance of those infested with *Phytophthora infestans* (De Bary), and may often be mistaken for the latter unless carefully examined. The disease often assumes the proportions of an epidemic. Yellowish-green, yellow bordered spots appear, which are covered on the under side with very fine, greenish-violet down. These spots often run into each other, forming large patches, which become brown.

The slender conidiophores emerge from the stomata on the under side of the leaf; conidia narrowed to a point, straight or slightly bent, almost hyaline, 1-4-septate, $12\text{-}50 \times 5\text{-}6\ \mu$.

Lagerheim, *Landt. handl. och Tidskr.*, 1903, p. 6.

Violet leaf spot.—Two or three distinct fungi form dry, whitish spots on the leaves of the sweet violet (*Viola odorata*), which present a somewhat similar appearance, and can only be discriminated with certainty by microscopic examination. *Cercospora violae* (Sacc.) is one of these, and often ruins whole batches of forced violets. When the plants are grown in the open air the disease is rare, and never assumes the proportions of an epidemic.

The fungus forms rounded, bleached spots that show

equally on both sides of the leaf, sporophores short, simple, greyish, 30-35 × 4 μ, conidia very long and slender, 150-200 × 3·5 μ, rod-shaped, many-septate, hyaline.

A disease that is very difficult to check when it once gains a foothold on plants growing in a frame, on account of the forcing methods practised, the crowded condition of the plants, and the constantly damp atmosphere and wet soil. The under leaves are attacked first, and these should be removed on the first appearance of the disease. At the same time the plants should be sprayed with dilute Bordeaux mixture; it is wise to spray once or twice in anticipation of the disease, before the flowers begin to show.

Mignonette leaf spot (*Cercospora resedae*, Fuckel) often attacks mignonette, more especially when grown under glass. Dry brownish spots appear on the leaves, causing them to turn yellow and die.

Conidiophores forming minute tufts on brown spots on the leaf, closely crowded, simple, continuous, or sparingly septate, straight below, rather wavy above, brown, 50-70 × 4-5 μ. Conidia acrogenous, narrowly obclavate, 4-5-septate hyaline, 100-140 × 2·5-3·5 μ.

Spraying with dilute Bordeaux mixture, as soon as the disease appears, arrests its progress.

Cercospora rubi (Sacc.) forms more or less circular, large, pale coloured, dry spots on bramble leaves.

Hyphae short, spores narrowly cylindrical, slightly tapering towards the apex, slightly curved, septa several, almost hyaline, 50-100 × 4·5 μ.

Cercospora odontoglossi (Prill. and Del.) attacks *Odontoglossum crispum.* The leaves assume a yellowish-green colour, and show blotches here and there of a greenish-olive tint which become covered with a delicate mould. The leaves are killed in rapid succession when the disease once gains a foothold.

Effused, velvety, olive-brown; sporophores erect, sometimes forked, sinuous, 100-150 × 3-4 μ; conidia elongated, narrowed upwards, 2-3-septate, hyaline then olive, 45-80 × 4-5 μ.

Sponging at intervals with a dilute solution of sulphate of copper is recommended.

Prillieux and Delacroix, *Bull. Myc. Soc. France*, 9, p. 270 (1893).

Cercospora viticola (Sacc.) forms irregular, dry, brown spots on vine leaves; most abundant during a damp season, and most abundant on the lower, shaded leaves.

Cercospora ceracella (Sacc.) attacks cultivated cherries. Forms roundish, brown spots with a grey centre on the leaves. Spores $50\text{-}90 \times 3{\cdot}5\text{-}4\ \mu$, very pale, slightly thickened at one end, 3-5-septate.

Cercospora beticola (Sacc.). This fungus is a very frequent parasite on the leaves of beetroot, but as a rule does not prove very injurious. It forms irregularly rounded, greyish dry blotches, bordered with reddish brown. The conidia are produced on the under surface of the leaf on the grey spots.

The short conidiophores burst through the epidermis in clusters, colour brownish; conidia narrowly club-shaped, attached by the broad end, multiseptate, hyaline, $60\text{-}140 \times 3\text{-}4{\cdot}5\ \mu$.

Prillieux, *Malad. des Plantes Agric.*, 2, p. 357 (1897).

FUSARIUM (Link.)

Spore-mass pulvinate or effused, more or less gelatinous when moist; conidia fusoid or falcate, typically many-septate at maturity, hyaline.

Sleeping disease of tomato.—This peculiar disease derives its name from the fact that apparently vigorous, full-grown plants suddenly wilt and droop, suggesting the idea of having gone to sleep, but which in reality proves to be the sleep of death. The malady was first observed in Guernsey, where large quantities of tomatoes are grown for the London markets. It has since been recorded from widely separated localities in England, although now, fortunately, it appears to be rarer than heretofore. When the epidemic was at its height, a loss of £100 to £200 was not unusual on a single tomato house.

Fusarium lycopersici (Sacc.) is the fungus in question.

The first suggestion of the presence of the disease is the wilting of the leaves, followed by a drooping of the upper and weaker portion of the stem, and within a few days the plant is dead. There is no sign of blotching or yellowing of the leaves, which are perfectly free from disease, the wilting being due to lack of water, the supply taken up by the roots

being prevented from ascending the stem, owing to the vessels being filled with mycelium. The root is the part first attacked, the fungus entering through the root-hairs and eventually forming a dense mass of mycelium in the vascular portion of the root and stem for some distance above the collar. If at this stage the stem is split open just above the collar, the vascular bundles are seen to be brown in colour, due to the presence of a brown substance in the

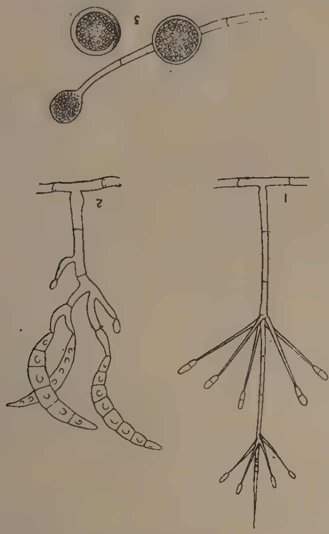

FIG. 148.—*Fusarium lycopersici*. 1, *Diplocladium* stage; 2, Fusarium stage; 3, resting spores. All highly mag.

vessels, caused by the mycelium. Shortly after the plant has drooped, the portion of stem just above ground becomes more or less covered with a delicate, white film of hyphae. This is the first conidial condition of the fungus, known as the *Diplocladium* stage. This is followed by a second or *Fusarium* stage, which originates from the same mycelium that produced the first stage. Numerous strands of mycelium spread from the roots into the soil, and there form resting-spores which remain in a passive condition in the soil until

the following season, when they germinate and infect the roots of young tomato plants.

These conidial stages obviously belong to the life-cycle of a *Nectria* closely allied to *N. solani*, if not identical with it, but I have not succeeded in obtaining the ascigerous condition, which probably only occurs on quite old, dry, dead portions of the stem or root.

The *Diplocladium* has erect branches bearing two or three whorls of branchlets; the hyaline, elliptical, 1-septate, conidia are borne singly at the tips of the branchlets, $5\text{-}6 \times 1{\cdot}5\ \mu$, but somewhat variable in size.

Fusarium conidia, fusiform, curved, 5-7-septate, hyaline, $45\text{-}80 \times 4\text{-}5\ \mu$. Chlamydospores or resting-spores, globose, hyaline, or tinged amber at maturity, terminal or interstitial, $18\text{-}35\ \mu$ diam.

As infection takes place underground, spraying is of no service. Plants should be removed and burned on the first clear symptoms of the disease, otherwise the *Fusarium* conidia, which are produced in immense numbers, are readily dispersed and infect other plants, and an epidemic is set up which it is most difficult to check. I have not succeeded in infecting a plant with the *Diplocladium* conidia. There is a tendency on the part of some growers to allow diseased plants to remain, arguing that half a crop is better than none; this, however, is false economy. Many growers firmly believe that the germs of the disease are carried in the seed. I have never been able to find mycelium in the seed, but I have frequently found *Fusarium* spores embedded in the glairy mass that surrounds the seed. Such spores, if placed in the soil along with the seed, would probably give origin to the disease. It is very risky using the soil that has produced a diseased crop for future crops; but remembering the great cost of removing and replacing soil in a house, suspected soil should be thoroughly mixed with gas lime, after which it should be allowed to remain for certainly ten weeks before anything is planted in it. Seed obtained from diseased fruit, or from a diseased area, should not be used.

Collenette, *Roy. Hort. Soc.*, 19, pt. 1 (1895).

Massee, *Gard. Chron.*, June 8, 1895.

Massee, above repeated in *Journ. Roy. Hort. Soc.*, 19, pt. 1 (1895).

Foot rot of orange and lemon.—This disease is widely distributed wherever the orange and lemon are grown. In Italy it is called *mal-di-goma*, and in Florida as foot-rot. *Fusarium limonis* (Briozi) is the fungus concerned. The indication of the disease is the accumulation of gum in patches near the base of the stem. The masses gradually increase in size and number, extending quite round the trunk and passing downwards into the branches of the root, destroying the tissues as it advances, and passing through the cambium zone into the wood. Soon the leaves are few in number, small and yellowish-green, and the young wood dies.

Spore-beds gregarious, white; conidiophores branched; conidia very variable, hyaline, oblong or fusiform, slightly curved, 1-3-septate, $25\text{-}27 \times 2\text{-}3\ \mu$.

The author states that the sweet seedling orange (*Citrus aurantium*) and lemon (*C. limonum*) are most subject to the disease, whereas the sour orange (*C. bigaradia*) is almost wholly exempt. Therefore sour orange stocks should be used on lowlands, and grape-fruit (*C. decumana*), which is also nearly exempt, should be used on higher grounds. The soil should be removed from around the crown by a strong jet of water, diseased bark cut away, and the wounds painted with carbolic acid. Good drainage and avoidance of much nitrogenous manure are also items to be remembered.

Briozi, *Mem. del. Acad. Lincei*, 1878.

Webber and Swingle, *U.S. Amer. Dep. Agric.*, *Bull.* 8 (1896).

Red mould of barley (*Fusarium heterosporum*, Nees., *Fusisporium hordei*, W. G. Sm., *Fusisporium lolii*, W. G. Sm.) is not a rare pest attacking the grain of wheat, rye, barley, and various grasses, as *Holcus*, *Lolium*, *Paspalum*, *Panicum*, *Molinia*, etc. It occurs in most European countries, Africa, and the United States. Barley attacked by this fungus is rendered useless for malting.

Grain that is attacked becomes swollen, and dense tufts of sphorophores burst through the pericarp and form orange, crimson, or dull deep red, somewhat gelatinous specks on the surface of the grain. Sometimes the entire ear is more or less covered with such a red mass, which is quite gelatinous when wet.

Spore-mass subgelatinous, deep red; conidia fusiform, curved, 3-5-septate at maturity.

Clean seed obtained from a district free from the disease should be sown. There is also a danger of infection from the presence of wild grasses.

Frank, *Jahrb. d. Deutsch. Landwirth. Gesell.*, 1892.
Matthews, *Journ. Roy. Mor. Soc.*, 1883, p. 321.
Smith, *Diseases of Field and Garden Crops*, p. 209.

FIG. 149.—*Fusarium heterosporum.* 1, portion of an ear of rye showing diseased grains; 2, diseased grains; 3, portion of a diseased grain showing the dense clusters of spores on its surface; 4, spores. Fig. 1 nat. size; remainder mag.

Red mould of Wheat (*Fusarium culmorum*, W. G. Sm.) is said by Smith to attack wheat, forming cream-coloured, yellow or orange, subgelatinous masses on the ear, gluing the various parts together and preventing the development of the grain. The conidia are said to be larger than those of *F. heterosporum*, fusiform, 3-5-septate, orange, soon breaking up at the septa.

A somewhat doubtful product, orange spores in *Fusarium* being an anomaly.

Smith, *Diseases of Field and Garden Crops*, p. 208.

Cotton frenching (*Fusarium vasinfectum*, Atkinson) is stated by Atkinson to be the cause of a cotton disease, which consists in a gradual discoloration of the foliage. The

leaf at first becomes pale yellow, beginning at the edge and gradually extending inwards, afterwards becoming brown. Mycelium causes the vascular bundles to assume a brown colour. Conidia of the *Fusarium* type, pluriseptate and slightly curved, were found. Plants that are attacked are either killed or so far injured that the crop is seriously affected.

Atkinson, *Alabama Agric. Expt. Station*, *Bull.* No. 41 (1892).

Flax wilt.—This disease, caused by *Fusarium lini* (Boll.), has long been known in Ireland, Holland, Belgium, and N. France, although curiously enough it is uncommon in Russia. In the United States it is a menace to the growth of flax. The term 'flax-sick' is applied to land that has produced a succession of crops that are diseased, and consequently infects the flax. The fungus is present in the soil, and is capable of living as a saprophyte, more especially on decaying portions of flax, and has been known to survive in the land for four years, during which period no flax was grown, after which the crop of flax wilted badly. Flax plants are attacked at all ages; if the soil is badly infected, most of the seedlings are killed before they appear above ground. Young plants suddenly wilt and soon die. Old plants that are quite woody often assume a yellowish, sickly appearance, wilt at the top, and gradually dry up and die. Death is caused by the mycelium of the fungus filling up the water-conducting system of the plant, which consequently wilts and dies owing to lack of water.

Spore-beds erumpent, pale-cream or flesh-colour. Conidia of the usual *Fusarium* type, fusiform, slightly curved, 27-38 $\times$ 3-3·5 μ.

Rotation of crops is recommended. Do not grow two crops of flax in succession on the same land. Burn as much of the flax stubble as possible. Avoid deep sowing; one-half to three-quarters of an inch is the best depth. The seed should be treated with formalin before sowing to destroy spores adhering to it. One part of formalin to 300 parts water for damping the seed.

Bolley, *U.S.A. Agric. Expt. Sta. N. Dakota*, *Bull.* 50.

Cherry flower bud disease.—Aderhold has described the

destruction of the flower buds of the sour cherry, due to *Fusarium gemmiperda* (Aderh.). The symptoms are similar to those caused by *Monilia*, and have probably often been passed over as such. The ascigerous condition of the fungus, probably a *Nectria*, was not discovered.

The conidia are of the usual *Fusarium* type, cylindrical with pointed ends, curved, 4-5-septate, hyaline, 35-45 × 4-5·5 μ.

Aderhold, *Zeitschr. Pflanzenkr.*, 11, p. 65 (1901).

Fusarium pannosum (Massee) forms extended, subgelatinous, bright red patches extending continuously for many inches, on living trunks of *Cornus macrophylla* (Wall.) in the Punjab. The fungus is thick and felt-like when dry, and is then of a clear bright vermilion colour. It must be very effective when seen *in situ*, and is probably an injurious parasite.

Fusarium gemmiperda (Aderhold) is described as attacking and destroying the flower buds of the wild cherry.

The spores are of the usual *Fusarium* type, 5-septate, 34-35 × 4-5·5 μ.

Aderhold, *Zeitschr. Pflanzenkr.*, 11, p. 65 (1901).

Fusarium loliaceum (Ducomet) forms numerous small, well-defined brown spots on the leaves of Italian rye-grass (*Lolium italicum*) in France. The present species closely resembles, superficially, *Fusarium hordearinum* (Ducomet), a parasite on barley. Both species have a well-developed layer of subcuticular mycelium, but in *F. loliaceum* the hyphae that pass from the subcuticular mass at a later stage, into the deeper tissues of the leaf, are intracellular, whereas the corresponding hyphae in *F. hordearinum* are exclusively intercellular.

Forming spots on the host. Mycelium subcuticular, then penetrating deeper. Conidia straight or slightly curved, hyaline, fusoid-claviform, apex obtuse, base slightly narrowed, continuous or often 1-septate, rarely 2-septate, 15-21 × 2·5 μ.

Ducomet, *Ann. l'École. Agric. Rennes*, 2 (1908).

FUSARIELLA (Sacc.)

Vegetative mycelium creeping, nearly colourless, giving origin to very short, erect, simple or branched conidiophores.

Conidia acrogenous, fusiform, usually curved, 2-many-septate, coloured.

Practically a *Fusarium* with coloured conidia.

Onion black mould.—Berkeley considered that *Fusariella atro-virens* (Berk.) was responsible for a destructive disease of onions, just before the period of reaching maturity. The fungus at first forms little dark-coloured dots with radiating mycelium. These dots eventually coalesce and form large jet-black blotches, the central portion bearing a greenish-black mass of spores, which are at first involved in mucus and form a glairy mass.

Conidia cylindric-fusiform, ends pointed, 3-septate, dark coloured, sometimes more or less strongly curved, often nearly or quite straight, $15\text{-}18 \times 5\ \mu$.

The intensely black patches resemble some *Torula* in general appearance. The fungus appears to be rare. Berkeley's type, in the Kew herbarium, is the only specimen I have seen.

HETEROSPORIUM (Klotzsch)

Conidiophores fasciculate, simple or sparingly septate, nodulose, septate, coloured; conidia solitary or in short chains, cylindric-oblong, 2-3-septate, minutely warted, coloured.

Often forming dingy olive patches. Only differing from *Helminthosporium* in the epispore of the conidia being minutely roughened.

Fairy-ring of carnations (*Heterosporium echinulatum*, Cke.) is destructive to cultivated carnations and pinks, especially when the plants have been exposed to a chill, or when a moist, warm spell in the spring is followed by a sudden lowering of the temperature. The fruit of the fungus appears in blackish dots, forming broken circles on bleached spots on the leaves. Minute sclerotia form in the tissues of dead, diseased leaves, and these are capable of producing conidia which infect plants the following season.

Conidia olive, minutely warted, 2-5-septate, $30\text{-}50 \times 10\text{-}15\ \mu$.

Pick off and burn infected leaves, and spray neighbouring healthy plants with a solution of potassium permanganate. Give good ventilation, and avoid watering the foliage.

Auricula leaf blotch, caused by *Heterosporium auriculi* (Mass.), a species remarkable for its very long, slender, often branched sporophores. The spores are not much wider than the sporophores, variable in length, $14\text{-}20 \times 5\text{-}6\ \mu$, often one-septate, steel-grey with an olive tinge. Three or four large olive-green patches are present on a leaf, and as a rule all the

FIG. 150.—*Heterosporium echinulatum*. 1, portion of a diseased carnation; 2, cluster of conidiophores bearing conidia; 3, conidium germinating, and producing secondary spores. Figs. 2 and 3 highly mag.

leaves of a plant are attacked, owing to the spores being washed from one leaf to another. When the fungus is mature the tissue of the injured spots becomes brown, and often crumbles away leaving a hole. On cultivated species of *Auricula*.

Excess of moisture favours the parasite. Spray with potassium sulphide and ventilate well.

Heterosporium gracile (Sacc.) is the cause of injury to the leaves of various cultivated plants—*Iris*, *Hemerocallis*, *Freesia*, *Antholyza*, etc., and is recorded from Europe, South Africa, New Zealand, and the United States. Large brown spots with a darker margin are usually present in considerable numbers on the leaves, which soon wilt and die in consequence.

Conidiophores olive, septate, nodulose, 70-90 × 10-14 μ. Conidia elliptic-oblong, 1-3-septate, ends blunt, minutely warted or granular, pale olive, 70 × 14-20 μ.

I found that spraying with ammoniacal copper solution checked the progress of the disease in the case of *Freesia recurva*. Probably sulphide of potassium would answer equally well.

Spinach leaf spot (*Heterosporium variabile*, Cooke) often forms roundish or irregular spots of a pale yellowish colour on the living leaves of spinach, which in consequence wilt and die. When the fungus is present in quantity the produce is often much reduced. When the diseased spots become clearly defined, the surface is studded with minute, dark-coloured tufts of fungus fruit.

Conidiophores flexuous, slender, more or less nodulose at the septa. Conidia cylindric-oblong, the larger ones 2-4-septate, epispore minutely warted, 20-25 × 7-10 μ. Conidiophores and conidia pale olive colour by transmitted light.

*** *Spores muriformly septate.*

SPORIDESMIUM (Link.)

Mycelium generally scanty, conidia ovate or obclavate, usually large, septate, becoming muriform, coloured.

Potato leaf blotch.—This is a disease well known on the Continent, also in Ireland, but has only quite recently been observed in Britain. The foliage is the part attacked, the parasite, *Sporidesmium solani varians* (Vañha), forming small, scattered, brown spots on the leaves. These spots gradually increase in size and fuse together, forming well-defined, blackish-brown patches. Leaves that are attacked soon turn blackish and die. When this happens somewhat

early in the season the crop is seriously curtailed. The general aspect of the diseased foliage closely resembles that due to *Phytophthora infestans*, but the spots are more sharply defined, and the fruit of the fungus is quite different to that of *Phytophthora*.

According to the author several forms are included in the life-cycle of the fungus, *Alternaria*, *Macrosporium*, *Cladosporium*, and *Phoma*. The last-mentioned form persists on the dead leaves during the winter, and starts the disease the following season.

Spots at first minute, blackish-brown, then expanding, and frequently occupying the entire leaf surface, at first angularly circular and sharply defined; sterile hyphae endogenous, filiform, flexuous, septate, branches pallid, becoming superficial and creeping, and producing here and there cylindrical, simple or sparingly branched, truncate, dusky conidiophores. Conidia very variable, typically obclavate, acrogenous, sometimes in short chains, 4-8-septate, one or other of the cells with a vertical septum, dusky, size variable, $20\text{-}50 \times 8\text{-}16\ \mu$, apex sometimes cuspidate and paler.

Spraying with half strength Bordeaux mixture is said to check the disease if applied on its first appearance. Diseased tops should be burned, as the *Phoma* present would continue the disease another season.

Vañha, J., *Mitteil. Landesl.-Versuchst. für Pflanzenkr., Brünn*, II., 1904.

Sporodesmium brassicae (Massee) is reported as causing considerable injury to *Brassica campestris* (L.), var. *Sarson* (Prain), at Tehroot, in the Bengal Presidency. The leaves, and more especially the pods are attacked, the fungus forming cloudy, olive-green patches that soon kill the part attacked.

Spots indeterminate, olive grey or green; conidia obclavate, pale brown, septate, becoming muriform, $160\text{-}200 \times 25\text{-}35\ \mu$. Conidiophores fasciculate, short, stout.

Massee, *Kew Bulletin*, 1901, p. 153.

ALTERNARIA (Nees.)

Hyphae fasciculate, somewhat erect, almost simple, short; conidia clavate, muriformly septate, produced in chains, but soon separating, coloured.

Violet spot disease.—This disease, caused by *Alternaria violae* (Dorsett), is said to be one of the most widespread and destructive maladies known to attack the violet in the United States. Plants are attacked at any stage of growth, from the small unrooted cutting to the mature plant in full flower. Plants of rapid, succulent growth are most subject to the disease. Any part may be attacked, but the injury is greatest when the leaves are injured. Greenish or yellowish spots first appear. As the disease extends, the spots present a waterlogged appearance, and are semi-transparent; afterwards, the affected spot bleaches, and eventually falls away, leaving a hole in the leaf. Unless checked, other spots appear until the entire leaf is destroyed. Clusters of spores are formed on the spots, and these quickly infect adjoining plants.

Conidiophores erect, pale olive, septate, simple, $25 \times 30 \times 4\ \mu$; conidia in chains at or near the apex of the conidiophores, clavately flask-shaped, muriform, strongly constricted at the septa, olive, $40\text{-}60 \times 10\text{-}17\ \mu$.

Bad cultivation, where much is expected without due attention to cleanliness and the selection of healthy and vigorous cuttings, is considered to favour the disease.

Dorsett, *U.S. Dept. Agric., Pathology and Physiology Div., Bull.* No. 23 (1900).

MACROSPORIUM (Fries.)

Usually forming blackish patches on living parts of plants. Conidiophores clustered; conidia dark coloured, muriformly septate, often constricted at the transverse septa.

Pycnidia and chlamydospores are present in some species.

Potato leaf curl.—Perhaps not one of the many diseases to which the potato is subject is less clearly understood than the present. This is because the general symptoms of the disease, viz., yellowing and curling of the leaves, followed by the collapse of the haulm, are by no means confined to the disease under consideration, but are equally present as a symptom of several other diseases, as in the case of Prillieux's 'filosite,' where the leaves are small and curled, and the stem long and slender. In this instance the cause is considered to be of a physiological nature, owing to the constant reproduction of the potato by vegetative methods.

In potato leaf-curl, as here understood, the leaves curl and the stem droops before there is any external evidence of the cause of injury. At a later stage, however, the stem and leaves bear numerous blackish-olive, minutely velvety patches of various form and size. The patches consist of dense masses of the dark-coloured conidia of *Macrosporium solani* (Cooke), the cause of the disease. As soon as the leaves begin to curl, a microscopic section of the stem reveals the presence of a dense mass of mycelium, which plugs the water-conducting parts, hence the leaves curl and the stem collapses owing to lack of water.

When a potato plant is badly infected, the mycelium passes from the haulm into the underground branches and young tubers, and I have explained in detail elsewhere a series of experiments proving that the mycelium present in a tuber used for 'seed' perpetuates the disease, which in turn again infects the young tubers. By means of such hibernating mycelium the disease is transmitted from generation to generation without the intervention of spores, or without ever leaving the host. This is exactly similar to what takes place in the case of *Phytophthora infestans*.

If the disease appears early in the season the crop is much reduced, many roots not producing more than a few very small tubers, some none at all. The conidia, so far as I have been able to ascertain, lose their power of germination, after a period of about three months, but, as a rule, numerous chlamydospores are produced in diseased leaves and haulms, and these bodies germinate readily the season following their formation, hence if such are present in the soil, there is every probability that potatoes planted in such land would become diseased. I stated in *A Text-Book of Plant Diseases*, p. 323, that the fungus there called *Macrosporium tomato* (Cooke) was very closely allied to, if not identical with, *Macrosporium solani* (Cooke). Subsequent experiments have proved this surmise to be correct; I have repeatedly produced the disease on tomatoes by inoculation with spores produced on a potato plant, and *vice versâ*. The disease on tomatoes is known as 'black rot' when it forms black blotches on the fruit, and 'black stripe' when it forms blackish lines on the stem. The mycelium is dark coloured in the region where beds of conidia are produced at the surface, but becomes colourless and thinner in the deeper tissues of the host.

Conidia brown, variable in size and form, clavate, oblong,

or with the apex somewhat narrowed, variously muriformly septate, 80-120 × 15-22 μ.

Chlamydospores formed in the decaying substance of diseased portions of the host, very irregular in form and size, dark brown, either interstitial or terminal, sometimes in chains.

Pycnidia often crowded, appearing along with or after the conidia; globose, black, with a small mouth, containing numerous minute, hyaline, elliptical conidia, about 3 × 2 μ.

Although I have not caused conidia more than three

FIG. 151.—*Macrosporium solani.* 1, tomato diseased; 2, conidia in various stages of development, highly mag.

months old to germinate, other observers have been more successful, and it is quite probable that old diseased stems or fruit lying about would continue to produce conidia the following season. At all events, chlamydospores are present in decaying parts, more especially in tomato fruit, consequently the most important point is to collect and destroy all diseased plants and fruit. Tomatoes should not follow a diseased crop of potatoes, or the reverse. If the disease appears, Bordeaux mixture would check its progress, so far as further infection from conidia is concerned.

Massee, *Journ. Bd. Agric.*, 13, p. 232 (1906).

Carnation macrosporium (*Macrosporium nobile*, Vize.) sometimes does a considerable amount of injury to cultivated carnations, forming numerous small blackish spots on both surfaces of the leaves and stem. The spots are irregularly scattered over the entire surface of the leaves when badly attacked, and the mycelium is rampant in the tissues, causing the leaves to turn yellow and die. Numerous small black

sclerotia are formed in the tissues of dead and dying parts, which produce spores the following season.

Conidiophores fasciculate, simple, short, erect, septate, brown; conidia large, subpiriform or rather irregular in form, tapering towards the tip, 4-10-septate, becoming muriform, constricted at the septa, brown, $60\text{-}80 \times 40\ \mu$.

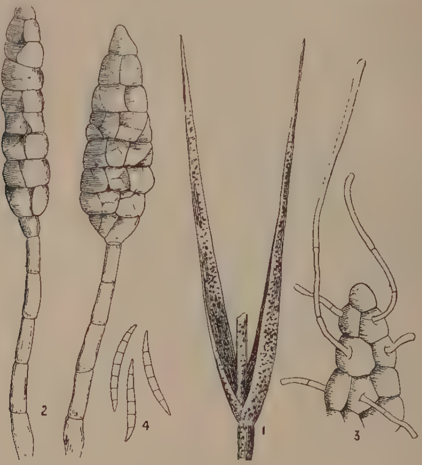

FIG. 152.—*Macrosporium nobile.* 1, portion of diseased carnation; 2, two conidia; 3, portion of conidium germinating; 4, *Fusarium* spores, mixed with, but no proof of any relationship with, the *Macrosporium.* Figs. 2, 3, and 4 highly mag.

Spray with ammoniacal copper sulphide, or with potassium sulphide, but as carnations will not bear too much moisture, much will depend on promptly removing leaves on the first appearance of the disease, which shows on the lowest leaves first. If the stems are attacked, and in all bad cases, the plants should be burned, not thrown on one side, otherwise the sclerotia will produce spores the following season, and endanger healthy plants.

Clover leaf spot.—Malkoff has noticed a clover disease in Germany caused by *Macrosporium sarcinaeforme* (Cav.). The fungus forms numerous minute dark brown spots on the leaves, which soon wither and die.

Conidia and conidiophores olive-brown. Conidia muriform, minutely warted, somewhat irregular in form, 25-33 × 16-22 μ.

Malkoff, Von K., *Zeit. Pflanzenkr.*, 12, p. 283 (1902).

MYSTROSPORIUM (Corda)

Conidiophores simple or sparingly branched, short, rigid, brown; conidia elongated, variously muriformly septate, dark coloured.

Closely allied to *Macrosporium*, differing in the darker coloured, rigid conidiophores and conidia.

Iris bulb scab (*Mystrosporium adustum*, Massee) sometimes destroys the bulbs of *Iris reticulata* by forming large, black, crusty patches on the outer sheath, the mycelium reaching to the heart of the bulb.

The hyphae form a dark-brown crust, some of the cells are often much swollen; conidia elliptic-oblong or ovate, ends obtuse, 5-7-septate, becoming muriform, sometimes with transverse septa only, 45-60 × 20-22 μ, smooth, dark brown, solitary on the tips of short branches.

I have found that if bulbs are only slightly attacked, that soaking for two hours in a solution of one part formalin to three hundred parts water will destroy the fungus without injuring the bulb. On the whole, however, it is wiser to destroy all infected bulbs, rather than run the risk of infecting the land.

Mystrosporium alliorium (Berk.) sometimes forms dark patches on onion bulbs.

Conidiophores brown, septate, often flexuous, conidia terminal or lateral, elliptic-oblong or subpiriform, constricted in the middle, becoming multi-septate and muriform, epispore brown, minutely warted, 30-45 × 8-12 μ.

Mystrosporium abrodens (Neuman) is destructive to the wheat crop in some districts in France. Dark patches appear on the leaves and nodes, the latter become weak and the plant bends over. The ears are arrested.

Neumann, *Soc. Biol. Toulouse*, 1892.

LICHENES

The majority of lichens are not parasites, and when growing on the bark of trees, are simply saprophytes, deriving no nourishment from the tree. On the other hand, when lichens are present in abundance on the bark of cultivated trees

FIG. 153.—*Usnea barbata* and *Ramalina fraxinea*, lichens growing on branch of apple-tree. Reduced.

they prove injurious to the extent of preventing the bark from performing its functions, and more especially in affording shelter to numerous forms of insect life which are decidedly injurious to vegetation. Lichens and mosses are killed by spraying with strong Bordeaux mixture or with a

solution of caustic soda, when the trees are in a resting condition.

In the tropics more especially, numerous species of lichens form more or less extended pale-green or whitish patches on the surface of evergreen, coriaceous leaves. Such species are undoubtedly more or less parasitic in habit, but as a rule do but little injury, unless present in sufficient quantity to cover the greater portion of the leaf, which is thereby prevented from performing its various functions. It has already been stated that a lichen is composed of one or more algae and a fungus, which work in unison. It would appear that in the case of *Cephaleuros mycoidea* (Karsten), the red rust of the tea plant, which is the most injurious lichen known, the algal element lives independently for a considerable time, and during this period is the cause of the trouble. When it combines with a fungus to form a true lichen it is no longer directly injurious.

Red rust of the tea plant.—The most destructive and at the same time the most widely distributed of pests attacking the tea plant in India. It is now known as *Cephaleurus mycoidea*, Karsten (=*Mycoidea parasitica*, Cunningham, *Cephaleurus virescens*, Kunze). Although the ultimate condition of this parasite is a true lichen bearing ascigerous fruit, its algal constituent usually remains for a considerable length of time perfectly free from the fungus component. In this stage it appears under the form of livid red, or orange-red spots of variable size on the leaves and branches. When a red tuft is examined under a magnifying-glass it is seen to consist of numerous erect threads, each ending in a little knob. In this form it is a decided parasite, and is capable of killing the branches. On the leaves the direct amount of injury is unimportant, but the spores produced enables the disease to spread to neighbouring bushes. On the leaf the patches are superficial and can be entirely removed with a sharp knife. The red algal element sometimes produces its own type of fruit, or it may be joined by a fungus and form grey or whitish, more or less polished, patches of lichen containing ascigerous fruit. On the stem the parasite behaves in a totally different manner, and proves very destructive. When once established the parasite penetrates the bark, which, in consequence, peels off in thin flakes; this process continues until the living tissues are reached, when the sap of the plant is absorbed by the parasite.

In addition to the tea plant, the parasite is commonly found on many trees in the jungle, more especially on those having coriaceous leaves, where it occurs much more frequently than on the branches.

Dr. Mann emphasises the point that *red rust is a disease of weak plants*, and that the primary aim of every planter who wishes to check the disease should be to strengthen the bushes, to seek out and deal with the causes of weakness—or otherwise every direct effort against the blight is bound to fail. The same author gives a summary of the principal conditions which may lead to an excessive development of red rust. Hard pan in the sub-soil. Lack of cultivation. Exhaustion of the soil. Susceptible type of plant. Unwise, heavy pruning. Too close plucking in the early part of a succession of seasons. Spraying with Bordeaux mixture under certain circumstances. All those interested in the cultivation of tea should become acquainted with Dr. Mann's original paper on the subject.

Cunningham, *Trans. Linn. Soc.* (Bot.), Ser. II., 1, p. 301 (1879).
Karsten, *Ann. Jard. Bot. Buitenzorg* (Java), 1891, pl. 4-6.
Mann, H. M. and Hutchinson, C. M., *Indian Tea Association*, Ed. 2, No. 4 (1904).
Marshall Ward, *Trans. Linn. Soc.* (Bot.), Ser. III., 2, p. 87 (1884).
Watt, Sir George, and Mann, H. M., *The Pests and Blights of the Tea Plant*, Ed. 2 (1903).

Cephaleurus parasiticus (Karsten) is common on the leaves of *Calathea* and *Pandanus* at Buitenzorg, Java. The epidermal cells contain the alga, which spreads over the leaf, blackening and killing it.

Karsten, *Ann. Jard. Bot. Buitenzorg*, 10, 1 pl. (1891).

Cephaleurus minus (Karsten) destroys the leaves of *Zizyphus jujuba*, in Java.

BACTERIA

Until somewhat recently it was held, even by many bacteriologists, that plants were practically free from diseases directly due to bacteria. The general reason given was that bacteria required an alkaline or at most a neutral medium for their development, such as is generally met with in the

animal kingdom, and that an acid medium, general in the vegetable kingdom, was inimical to their development. In spite of this generalisation, it is now well known that bacteria are the primary cause of several of the most destructive of plant diseases. This knowledge we owe more especially to the valuable research conducted by Dr. Erwin F. Smith, director of the Laboratory of Plant Pathology, U.S. Dept. of Agriculture.

Smith, Erwin F., *Bacteria in Relation to Plant Diseases*, vol. i. (1905).

Potter has recently stated that bacteria are active agents in the oxidation of amorphous carbon. His summary on the subject is as follows:

Under conditions of exposure to the air, a slow oxidation of amorphous carbon takes place through the agency of bacteria. This has been conclusively established by experiments upon such carbonaceous substances as charcoal, lampblack, coal, and peat.

When these substances are subjected to bacterial action carbonic acid is given off, as estimated volumetrically by absorption in baryta solution and titration with standard oxalic and hydrochloric acids.

The amount of CO_2 given off increases in proportion to the rise of temperature and ceases to be evolved at a supravital temperature. There is no evolution of CO_2 under perfectly airy conditions such as preclude the possibility of bacterial life.

A distinct rise of temperature occurs through the action of bacteria. The heat generated was determined by measurement, with a galvanometer of the electromotive force produced by the difference of temperature between two thermo-elements, one placed in a sterile and the other in an inoculated flask.

The evolution of CO_2 and the accompanying rise of temperature does not take place when carbonaceous substances are preserved from the intrusion of micro-organisms.

The heat generated by microbial activity is an influence to be taken into account in connection with the oxidation and spontaneous combustion of coal; it may be a dangerous motive force acting upon explosive gases.

The oxidising action of bacteria must be largely responsible for the disintegration of coal and the high percentage of depreciation which it undergoes in store.

Coal and peat, like other organic matter, are liable to decomposition as soon as conditions are presented suitable for the life of aërobic organisms. The carbon is then once more liberated, in the form of CO_2, to play its *rôle* in the life-cycle. It is thus conceivable that the vast supplies of carbon locked up in the world's coal-fields may become available for plant nutrition without the intervention of direct combustion.

Potter, M. C., 'Bacteria as Agents in the Oxidation of Amorphous Carbon,' *Proc. Roy. Soc.*, Ser. B, 80, 239 (1908).

Black rot of cabbage.—A serious bacterial disease of cabbages, caused by *Pseudomonas campestris* (Smith), has

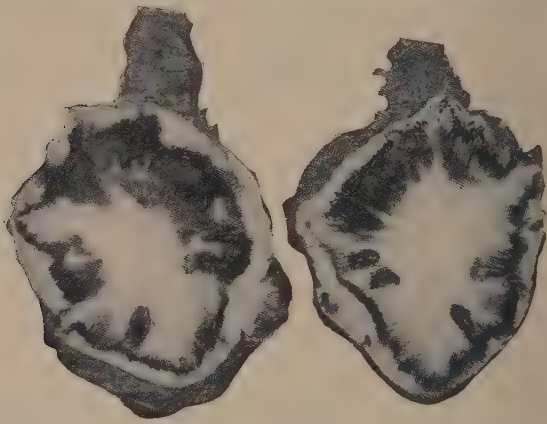

FIG. 154.—*Pseudomonas campestris*, causing bacteriosis in cabbage; cabbage skin cut across, showing the discoloration caused by the organism.

long been known in the United States, where it sometimes devastates the entire crop in a field in a very short period of time. It has also been recorded from several European countries, and was first observed in England in 1902. In addition to cabbages, many other members of the Cruciferae are also attacked, as brussels-sprouts, kale, rape, broccoli, radish, turnips, both white and swedes, etc. The fibro-vascular bundles are attacked and soon turn black, a character by which this disease can be recognised; the veins of a diseased leaf become quite black and are very conspicuous,

and if the stem of a diseased plant is cut across, the vascular system also shows up as a black ring. The bacteria enter the leaf through certain minute openings—water stomata—present along the margin, where they rapidly increase in numbers and work along the veins, and down the leaf-stalk into the stem, from where they soon pass out into other leaves. The bacteria also enter the leaf through wounds made by insects, by whom they are also conveyed from one plant to another.

Smith fed slugs on diseased cabbage leaves, and afterwards placed the slugs on healthy leaves, on which the disease appeared a week or two later.

When the soil is infected the germs also pass into young plants through broken roots at the time of transplanting. Diseased plants soon collapse with soft rot and form a loathsome, foul-smelling mass.

Harding, Stewart, and Prucha have proved by an extensive series of experiments that the bacterium causing black rot of cabbages, etc., can survive the winter on the seed, and that much of the cabbage seed on the market is contaminated with germs, which may become a source of infection to the young cabbage plants.

Diseased plants should be removed and buried along with gas-lime, or burned. Such plants can readily be detected by the black veins, and by the black points in the tissue when the leaf-stalk is broken across.

Respecting the seed, Harding says: 'As a precautionary measure, it is advised that all cabbage seed be disinfected before sowing, by soaking for fifteen minutes in a 1-1000 corrosive sublimate solution or in formalin, one pound to thirty gallons [water]. It is not expected that this treatment will prevent either leaf or root infection in infected soils; but it may be safely relied upon to prevent all danger from infected seed. It will not injure the germination.'

I have observed that rape is most susceptible to this disease in England; in one extensive trial plot of various kinds of cabbages, savoys, etc., those that were known to have a certain amount of 'rape blood' in them were first diseased, whereas those free from this element were the last to succumb.

Smith, E. F., *Zeitschr. für Pflanzenkr.*, 8, p. 1.

Harding, H. A., Stewart, F. C., and Prucha, M. J., *New York Agr. Exp. St.*, *Bull.* No. 251 (1904).

Black rot of horse-radish.—During the past season an extensive outbreak of black rot, caused by *Pseudomonas campestris* (Smith), has been recorded as attacking horse-radish. The symptoms are identical with those described under black rot of cabbage. It is highly probable that all plants belonging to the order Cruciferae are susceptible to this disease.

Maize disease.—Prof. E. F. Smith has now proved that *Pseudomonas Stewarti* is the cause of the sweet corn disease of Long Island. The organism is rod-shaped, with a polar cilium, $1\text{-}2 \times 0{\cdot}5\text{-}0{\cdot}9\ \mu$, and occurs in the vascular bundles. It is yellow, aërobic, but capable of becoming anaërobic.

Smith, E. F., *Proc. Amer. Assoc. Sci.*, 47, p. 422 (1898).
Smith, E. F., *Proc. Amer. Assoc. Sci.*, N. S., 17, p. 458 (1903).

Bacterial disease of lilac.—A disease of lilac, not at all uncommon in this country, has been shown by Dr. Klebahn to be due to bacteria. In May or the beginning of June, when the young shoots are yet soft and tender, the internodes and young leaves often show large, blackish blotches, due to the presence of bacteria, which occupy the intercellular spaces. The organism is called *Pseudomonas syringae* (Hall).

Klebahn, H., *Krankheiten des Flieders*, p. 5 (1905).

Black dry rot in swedes.—Professor Potter describes a dry rot of swedes, caused by a bacterium belonging to the genus *Pseudomonas*. Externally the plants show but little evidence of disease; however, when the root is cut open, the centre is seen to consist of a blackish mass of disorganised tissue, in which are numerous cracks and cavities. In a more advanced stage of disease the root becomes hollow, the rind alone remaining as a mere shell. During decay the bulb remains fairly dry.

'The special bacterium causing this rot in the swede is a short, motile rod $3\ \mu \times 1\ \mu$. It is an aërobic form, liquifying 5 per cent. gelatine. Great difficulty has been found in staining the flàgella, but by using the well-known methods of Van Ermengen and of Löwitt I have been able to determine the presence of a single polar flagellum, and, hence, adopting Migula's classification, it must be placed in his genus *Pseudomonas*.

Potter, *Journ. Bd. Agric.*, 9, p. 28 (1902).

Potato bacteriosis.—A very distinct and well marked bacterial disease, caused by *Bacillus solanacearum* (E. F. Smith), has been recorded in the north of England and in Scotland. The disease has been known for some time in

FIG. 155.—Bacteriosis of potatoes. Potatoes cut in half showing the disease. Fig. 1, early stage; 2, later stage.

the United States, and has been carefully studied by Dr. E. F. Smith. A marked characteristic of the bacterium causing this disease is the production of a brown colouring

matter in the tissues infested, hence the course of the disease can be clearly followed in the haulm and tubers.

The presence of the parasite is first indicated by the wilting and shrivelling of the leaves. Soon afterwards dark brown streaks appear on the haulm; these streaks gradually extend downwards and pass along the underground branches into the tubers. Once in the tuber, the disease shows as an imperfectly formed pale brown ring, situated at some little distance from the outside of the tuber, and corresponding to the vascular bundle zone of the tuber. As the disease progresses the brown ring becomes broader and darker in colour until finally only the skin remains, the entire starchy portion of the tuber having crumbled to powder and the myriads of bacteria it contained are liberated in the soil, where they live until an opportunity is offered for infecting another crop.

The leaves and stem are as a rule first infected, the bacteria gradually following the vascular bundles of the stem down into the tuber. In some instances infection of the tubers may take place directly by bacteria present in the soil. Dr. Smith considers that the rapid spread of the disease is caused by insects of various kinds, feeding alternately on diseased and healthy plants.

To prevent such an epidemic, when the disease is known to be present, the crop should be thoroughly sprayed with an insecticide, or better, with Bordeaux mixture containing an insecticide, such a wash being protective against both insects and *Phytophthora infestans*. Diseased tubers should be gathered and burned, not buried, nor thrown on the manure heap.

When the disease is present and shows a tendency to spread, the crop should be lifted at the earliest opportunity, as by so doing many of the tubers may be saved if allowed to dry thoroughly on the land, and afterwards used as soon as convenient. Potatoes showing indications of an internal brown ring should not be used for 'sets.'

Smith, Erwin F., *U.S. Dept. Agric.*, *Bull.* No. 12 (1896).

Blackleg of potatoes.—This disease is due to a bacterium called *Bacillus phytophthorus*. It has been known for some time on the Continent, but fortunately it is as yet rare in Britain; there is reason, however, to fear that it is spreading with us. It is very destructive in its effects, and in Germany

the loss caused by it is often 10 to 15 per cent., and sometimes up to 75 per cent. of the entire crop.

The disease is indicated by the following characters. The leaves wilt and turn yellow, then shrivel and die, starting first low down on the stem, the uppermost ones being the last to succumb. When the leaves begin to droop, the surface of the underground part of the stem bearing such leaves is more or less covered with brownish stains. This discoloration gradually extends up the stem, which finally becomes quite black and soon decays. Black patches also appear on the young tubers, and the vascular ring situated some little distance within the periphery of the tuber is often blackened. When the bacterium has once commenced to decompose the tissues, various other bacteria and fungi assist in bringing about the general decomposition of the potato plant.

The disease spreads rapidly during damp, hot weather, and is most abundant during the months of June and July. When an epidemic occurs early in the season, the decaying haulms infect the soil and also the young tubers. In fact it may be assumed with certainty that land having produced a diseased crop is infected.

The following preventive measures are suggested by Dr. Otto Appel, who has studied this disease in Germany.

(1) Potatoes, beans, carrots, cucumbers, turnips, vegetable marrows, beet, and mangolds are all susceptible to this disease, and should not be cultivated for two years on land where the disease has occurred.

(2) Cereals are not attacked.

(3) Potato 'sets' should not be cut.

(4) Care should be taken to obtain 'sets' from districts where the disease does not exist.

(5) Lime or strong nitrogenous manures, especially nitrate of soda and sulphate of ammonia, should not be used.

Carruthers has described a bacterial disease of beans from a field in Norfolk as follows:

'The attack had begun in the root and passed up into the stem, suggesting the disease of blackleg in the potato plant. The parts killed in both the root and stem were filled with a greyish shiny substance swarming with innumerable very minute rod-like bacteria. The bacterium was isolated and cultivated on sterilised carrot. It grew very freely, forming gelatinous, dirty white colonies. From these the bacteria were transferred on a needle to young seedling beans. The bacteria began to

multiply, and in four days the blackness of the rootlets and the stem as in the original specimens made its appearance. The examination of the blackened tissues showed that the injury was due to the same bacteria. A further experiment was made to test whether this bacterium of the bean was the same as that causing blackleg in potato. Bacteria from the beans were transferred to healthy potato tubers, which were planted in the soil. The shoots that were developed were healthy, but after direct infection of the shoots the disease appeared and they were killed. Those results may not be sufficient to determine the identity of the bacterium causing blackleg in potatoes and in beans; it nevertheless establishes that the potato may be infected by the bacterium from the bean. It is therefore well that caution be exercised when an attack of blackleg appears in a crop of either beans or potatoes; neither plant should be the succeeding crop.'

Carruthers, W., *Journ. Roy. Agr. Soc. Eng.*, 68, p. 226 (1907).

Yellowing of beetroot leaves. — Delacroix describes a bacterial disease of beetroot in France, which at times causes serious loss. Sugar beet and mangolds are equally attacked. The disease is readily recognised by the presence of irregular patches of a pale-green colour on the leaves. Numerous mobile bacteria are present in the cells of such discoloured patches. Similar organisms are present in the tissues of the leaf-stalk, root, calyx, and fruit. The organism proved to be new, and received the name of *Bacillus tabificans* (G. Delacroix). It is shortly oval, $1{\cdot}5 \times 1\ \mu$. No vibratile cilia or production of spores observed.

The preventive methods suggested are: (1) A three years' rotation; (2) Burn all diseased plants; (3) Only sow seed that is four years old.

Prillieux, *Comp. Rend.*, 37, p. 871 (1903).

Bacterial tumours of the olive.—Numerous irregularly globose nodules, furnished with a central depression, and irregularly wrinkled surface, are often present on branches of the olive-tree. The branches thus attacked soon perish, and trees that are badly infested are recognised at a distance by the wilted, sickly-looking foliage. These nodules or tumours are quite woody in consistency, and are caused by a bacterium known as *Bacterium savastanoi*, E. F. Smith (sym. *Bacillus*

oleae, Trev.). The disease occurs throughout the Mediterranean region wherever the olive is grown, and it is also present in California. So far as is at present known the organism can only effect an entrance into the plant through wounds. When a nodule is once produced, it has been proved that the bacteria may migrate to some distance by way of the vascular system, and form other tubercles which thus originate from within the host. These tubercles finally rupture the epidermis and form nodules.

The organism consists of cylindrical rods with rounded ends, singly or in short chains, $1{\cdot}2\text{-}3 \times 0{\cdot}4\text{-}0{\cdot}8\ \mu$. The organism is motile, having 1-4 polar flagellae.

Rich soil, too much manure, and too much water favour the disease. Pruning all diseased branches checks the disease, but it is important that a knife used for removing diseased branches or cutting out tubercles should be sterilised before it is used on healthy parts. Large tubercles should have a portion of the underlying wood also removed, and the wound should be at once sterilised and protected.

Pierce, *Journ. Mycol.*, 6, p. 148.

Savastano, *Ann. R. Scuola Sup. d'Agric. in Portici*, 5, fasc. 5 (1887).

Smith, E. W., *U.S. Dept. Agric.*, *Bureau of Plant Industry*, *Bull.* No. 131, pt. 4 (1908).

Voglino, *I Fungi Dannosi alle, Piante Coltivate.*

Calla lily rot.—Dr. Townsend has described a soft rot of the Calla lily in the United States, caused by *Bacillus aroideae* (Townsend). The disease is present in the bulb, leaves, and flower-stem. The white substance of the bulb becomes brown and watery. The leaves and flower-stem are spotted with a dark colour. The plant is eventually killed.

Townsend, C., *U.S. Dept. Agric.*, *Bur. Pl. Industry*, *Bull.* 30 (1904).

Cherry-tree bacteriosis.—A serious disease of cherry-trees caused by *Bacillus spongiosus* (Aderh. and Ruhl.) is recorded from Germany. Both young and old trees suffer, in some instances to the extent of 50 to 60 per cent. The bark is the part attacked, the injured portions exuding a gummy substance in drops or sometimes in large quantities. Large crevices appear in the bark and extend for some distance inwards, and contain masses of gum and of bacteria.

The organism is rod-shaped, ends rounded and ciliate.

This disease is said not to be identical with the American pear blight, due to *Bacillus amylovorus*.

Aderhold and Ruhland, *Sond. Arb. d. Kais. Biol. Anst. für Land. u. Forstu.*, 5 (1907).

Stem rot or blackleg of tobacco.—This disease of tobacco is well known and widely distributed in Japan. It is caused by *Bacillus nicotianae* (Uyeda). The symptoms of its presence are, yellowing of the leaves, blackening of the stem, and finally the complete destruction of the root. The symptoms thus are somewhat similar to those caused in the tomato by *Bacillus solanacearum*.

The organism is rod-shaped, ends rounded and ciliate, $1\text{-}1{\cdot}5 \times 0{\cdot}5\text{-}0{\cdot}7\ \mu$. Differs from *B. solanacearum* in physiological and morphological points. Infection takes place through the root-hairs, through stomata or wounds. Dampness and a high temperature favours the disease.

Acid manures check the bacillus when present in the soil. Alkaline manures do not.

Uyeda, Y., *Bull. Imp. Cent. Expt. Sta. Japan*, i. p. 1 (1905).

Blight canker of apple-trees. — This is due to the same organism (*Bacillus amylovorus*, de Toni) that causes pear blight. It attacks trees of any age, but is most destructive to trees just coming into bearing. Canker spots appear as discoloured and somewhat sunken areas, the advancing margin being usually slightly raised and blistered. On damp, cloudy days drops of a cloudy, milky fluid exude from cankered tissues through the lenticels or pores in the bark. Soon the diseased tissue turns brown and dies. Such patches are well defined by a crack along the line where the diseased tissue has separated from the healthy bark. The progress of canker is favoured by a humid atmosphere and cloudy days, and is checked abruptly by bright sunny weather. Many cankers are active for one season only and do but little harm, others, however, continue for a succession of seasons, girdling the branch or trunk as the case may be, and finally killing the tree. Canker spots vary in diameter from half an inch upwards; some are a foot or more in length and several inches across. On vigorous trees they are small and circular in outline, and form funnel-shaped wounds in the wood; these do not seriously injure the tree directly, but facilitate the

entrance of fungi, etc. Symptoms of the disease are the scanty, pale, small, more or less curled leaves, on a given branch or over the whole tree, depending where the canker is located. It is most fatal when the collar or the angles formed by the larger branches are attacked. Infection takes place, often through the unconscious agency of insects, at points of the bark that have been bruised or wounded in any way, and also through the blighting of adventitious shoots on the trunk or limbs.

Whetzel, H. H., *Cornell Univ. Expt. Sta.*, *Bull.* 236 (1906).

Mulberry bacteriosis.—The arrest of the growth of young mulberry trees has been noted by Boyer and Lambert in France, who traced the injury to a bacterium they have named *Bacterium mori*. The injury consists in the arrest of development of the branches, which is first indicated by the presence of blackish-brown patches on the lower surface of the leaves and young branches. On the branches the spots vary in form, generally elongated and depressed, which eventually become open wounds extending to the pith.

Boyer and Lambert, *Comp. Rend.*, 128, p. 342 (1893).

Iris rot.—This disease is very prevalent in this country, also on the Continent, and attacks many different kinds of iris. I have repeatedly seen whole beds completely destroyed by it. A single plant may first show the disease, which is indicated by the wilting of the leaves, which soon become yellow and die. On removing such a diseased plant, it is found that the portion immediately underground is quite soft and rotten. This condition of things often extends to the rhizome, and when this is the case all offshoots from the rhizome are also infected.

Dr. C. J. J. van Hall has proved by a series of experiments that the disease is due to bacteria, the most potent factor being *Bacillus omnivorus*, v. Hall; *Pseudomonas iridis* and *Pseudomonas fluorescens exitiosus* are also capable of producing the same disease.

Plants should be taken up and burned on the first indication of the disease. I have found that a liberal use of superphosphate of lime checks the disease and disinfects the soil. Quicklime favours the disease. The rhizomes of diseased plants should be examined and all soft parts cut away. Neither

should portions of plants that have shown the disease be used for propagation.

Hall, C. J. J. van, *Zeitschr. Pflanzenkr.*, 13, p. 129 (1903).

Orchid gummosis.—Professor Potter has shown that a leaf spot, occurring more especially on the older leaves of *Odontoglossum uro-skinneri*, is caused by a bacterium. The spots are often crowded together, the smallest barely visible to the naked eye, the largest, elliptical in shape, may attain a long diameter of half a centimetre. When large, the spot is raised above the surface of the leaf, and looks like a blister, surrounded by a translucent border. A brown mucilaginous substance is present in the tissues under the epidermis in the region of the spots; deeper down in the substance of the leaf the mucilage is white. It is the accumulation of this substance that raises the epidermis and forms the blister.

The disease is most prevalent when the plant is grown in a very moist atmosphere, and is very liable to spread. In a dry atmosphere it does not spread, and disease already present is checked.

Potter, *Gard. Chron.*, March 6, 1909, p. 145.

Ash canker.—The four or five year old stems or branches of young ash-trees are frequently disfigured by the presence of cankered spots, varying in size from small cracks with thickened margins, half an inch long, up to rugged patches forming irregular cavities in the wood, and bounded by irregular outgrowths of callus, which may extend for several inches. These diseased spots have been shown by Noack to be of bacterial origin. In some instances, at least, the leaves and leaf-stalks appear to be first infected, the bacteria from thence passing into the wood. On the branches small, discoloured, reddish patches of bark first indicate the presence of the disease. The bark eventually cracks at these points, and the canker gradually increases in size, the disintegration of the tissue being frequently accelerated by fungi that gain an entrance through the wounds in the bark.

The bacteria are in the form of short cylindrical rods, and are sometimes slightly bent and thickened at the ends. When stained and mounted the rods measure $2 \cdot 6 \times 0 \cdot 5\ \mu$.

Noack, F., *Zeitschr. Pflanzenkr.*, 3, p. 191 (1893).

Ivy canker.—Dr. G. Lindau has described a canker on the stems of the ivy caused by a bacterium. At first small dark-

coloured patches appear on the bark; these patches eventually crack, and as the wound expands it becomes surrounded by an irregular, rugged, raised border; the canker in some instances measures an inch in length. The leaves are also attacked; small brown patches appear mostly on the upper side, the tissue becomes thickened at these places, and finally breaks open in an irregular manner. The general characteristics of the disease resemble those described under the Ash. The rod-shaped organisms measure about $2 \times 0{\cdot}3\ \mu$.

Lindau, *Zeit. Pflanzenkr.*, 4, p. 1 (1894).

Sugar-beet gummosis.—Busse has described a disease of sugar-beet caused by a bacterium, in which the flesh situated between the vascular bundles of the root is converted into a gum-like substance. The vascular bundles also become blackened.

The bacterium consists of short rods with rounded ends, $1{\cdot}75\text{-}2 \times 0{\cdot}9\ \mu$, sometimes almost egg-shaped. Diphlobacteria are abundant; very motile.

Busse, W., *Zeitschr. Pflanzenkr.*, 7, pp. 65 and 149 (1897).

Sesamum leaf blotch.—Malkoff describes a bacterial disease of *Sesamum orientale* from Bulgaria. Dark-brown spots appear on the leaves, which soon become blackish and shrivel. A thick slimy mass exudes from the diseased spots, which, when introduced into healthy plants, produced the disease. Two bacteria were isolated, but not studied.

Malkoff, K., *Centralb. f. Bakt. Abt.*, 2, vol. ii. (1903).

Vine gummosis.—A disease, known in Italy as 'mal nero, has for a long time been known as very destructive to vines. It has also appeared in certain districts in France. Diseased vines are stunted in growth, the young branches do not attain their full development, and the leaves are deformed and often show deep incisions. If the stem is cut across, black points are seen to be present in the wood. These spots increase in size and run into each other, forming large patches. At the end the parts attacked become brown. The injury starts in the stem and passes downwards into the root. At the same time radial fissures appear in the bark. Structures resembling lenticels are usually produced in abundance on the diseased portions of the stem. The wood underneath the diseased portions of bark undergoes great changes, which results in

the formation of a gummy substance containing myriads of bacteria.

On cultivation, filaments of a *Leptothrix* form were observed, the joints of which on separation showed mobile bacteria 0·75 to 1·25 μ in length.

It is recommended to cut out all diseased parts, and protect the wounds with gas-tar. But the safest method is to remove and burn all diseased vines.

Prillieux, Ed., *Malad. des Plantes. Agric.*, i. p. 24 (1895).

Root swellings of alder.—Swellings on the roots of *Alnus incana* and other species are well known. They vary in size from a marble to that of a cricket-ball. In some cases the swelling is a solid body with a tuberculose surface, suggesting a mass of crowded, adventitious roots grown together except at the extreme tips. In other instances, more especially when the swellings are small, they are composed of root-like outgrowths more or less free from each other.

Waronin was the first to investigate these swellings, and came to the conclusion that they were due to a fungus, which he called *Schinzia alni.*

Möller considered the organism present to be a myxomycete, to which he gave the name of *Plasmodiaphora alni.*

Brunchorst found a fungus in the swellings, which he named *Frankia subtilis.*

The last to investigate the subject was Björkenheim, who observed fungus hyphae 3·5-4 μ thick, possessing a distinct wall with a double contour, and distinctly septate. These hyphae pass through the cell walls of the host, and often form a dense convoluted mass, completely filling the cells. Fruit unknown.

Björkenheim, C. J., *Zeit. Pflanzenkr.*, 14, p. 130.

Brunchorst, J., *Unters aus dem Bot. Inst. zu Tubingen*, 2, p. 151 (1886).

Möller, *Ber. d. deutsch. Bot. Ges.*, 3, p. 102.

Woronin, *Mem. Acad. Imp. St. Petersb.*, Ser. 7, vol. x., No. 6.

Bacterial knots.—Zimmermann has announced the presence of small colonies of bacteria in living leaves of *Pavetta indica.* These colonies are constantly present in the leaves of this plant, and occupy the air cavities below the stomata, a minute wart or knot on the surface of the leaf indicating

their presence. Their significance, if any, in the economy of the plant is unknown. They are not parasitic.

Zimmermann, A., *Pringsh. Jahrb.*, 37, p. 1 (1901).

Myco-bacterial disease of fungi.—Vuillemin gives an account of the discovery of a number of deformed specimens of *Tricholoma terreum* (Fr.), a species much sought after as an article of food by mycophagists in France. The malady presents three distinct symptoms, deformation, sterilisation, or arrest of spore formation, and decomposition of the tissues, which takes place quickly, the central flesh of the fungus becoming quite soft and putrescent when the surface still appears to be quite sound.

The first and second of these symptoms was proved to be due to the action of *Mycogone rosea*. The putrefaction of the fungus, on the other hand, was found to be due to bacteria, introduced into the flesh of the fungus through the mycelium of the parasite, *Mycogone*. Numerous zooglaea of immobile bacteria $2{\cdot}5\text{-}3{\cdot}5 \times 0{\cdot}5\ \mu$, or reaching up to $6\ \mu$ long, and then divided into two cells by a septum. Sometimes the rods contain a spore.

The author considers it highly probable that the injury to the cultivated mushroom, attributed to *Mycogone perniciosa*, is in reality caused by the combined action of the *Mycogone* and a bacterium.

M. rosea forms suffused, velvety, rose-coloured patches, hyphae slender, colourless, densely interwoven; conidia obovate, tinged red, two-celled, upper cell largest, warted, lower cell paler and smooth, $35\text{-}4 \times 20\text{-}25\ \mu$.

Vuillemin, *Comp. Rend.*, 119, p. 811 (1894).

MYXOGASTRES

This group of organisms, also known as Myxomycetes and Mycetozoa, was at one time considered as belonging to the fungi. The discovery, however, that the spores on germination, instead of producing a germ-tube, give origin to amoeboid bodies possessed of the power of spontaneous movement, which combine to form a solid mass or plasmodium, also possessed of the power of movement, placed these organisms outside the fungi, and according to some authorities, outside the vegetable kingdom, hence the name Mycetozoa.

The plasmodium or vegetative condition remains buried in the matrix from which it obtains food, until ready to form spores, when, for the object of effecting the wide dispersion of the spores, it creeps to the surface and forms its sporangia in a position where the spores will be readily dispersed by wind, etc.

The group is cosmopolitan in its distribution, although numerically small—under five hundred species. The majority are minute, and live as saprophytes amongst humus, dead wood, etc.; on the other hand, a few species are amongst the most destructive of known parasites.

Some of the larger species that are not parasitic, creep over living plants and suffocate seedlings. The dense masses of spores sometimes prove injurious to animals.

Finger-and-toe, also known in different districts as 'Club-root,' 'Anbury,' 'Grub,' etc., is caused by a Myxogaster called *Plasmodiophora brassicae* (Woronin).

Nearly all kinds of cruciferous plants, both wild and cultivated, are attacked. The cultivated plants that suffer most in this country are turnips and the various kinds of cabbage. The root is the part attacked, which becomes much distorted and more or less covered with large swellings or finger-like outgrowths. Finally the entire root is resolved into a loathsome, rotten, foetid mass.

Infection is effected by swarm-spores liberated from spores present in the soil. These swarm-spores enter through the delicate root-hairs, and pass into the root, where they stimulate a rapid increase in the number of cells. The infested cells also increase enormously in size and become filled with the plasmodium or vegetative condition of the organism, which at a later stage become transformed into a mass of spherical spores about 3 μ in diameter.

When the root decays, these spores are liberated in the soil, and in due course infect future crops.

This disease has undoubtedly increased very much in severity in this country during the past fifty years. This period agrees roughly with the cessation of the previous general use of lime in favour of artificial manures, crushed bones, etc., many of which contain crude acid. Now it has been proved that the presence of an acid greatly favours the development of *Plasmodiophora*, in fact it may be said to be indispensable. On the other hand, the presence of an

alkali is decidedly detrimental to its development, and as the use of acid manures is very general at the present day, it will be seen that much more land is rendered favourable for the development of *Plasmodiophora* than in bygone times.

Lime is the best and most practical preventive of finger-

FIG. 156.—*Plasmodiophora brassicae*, causing finger-and-toe of root of Brussels-sprout.

and-toe known; from five to seven tons per acre, to be applied in the autumn, either six months or eighteen months before the turnips are sown. A second method, also recommended, is to apply the lime immediately after a diseased crop of turnips is removed; about two tons will suffice if it is spread evenly over the land. Such a dressing will produce no visible effect on finger-and-toe until the next crop of turnips is grown, but it may prove to be of value to intervening crops.

It is important to bear in mind that plants can, as a rule,

only be infected during the seedling, or quite early period of growth, hence, if seed-beds for the various kinds of cabbage are properly limed, the plants will grow up free from disease.

FIG 157.—*Plasmodiophora brassicae.* 1, young turnip showing early stage of disease; 2, cabbage showing clubbed root; 3, two infected cells from root of cabbage, one containing plasmodium, the other crowded with minute spores of the parasite; 4, three myxamoebae or motile bodies produced by the spores on germination. Figs. 3 and 4 highly mag.

It will be impossible to stamp out the disease unless proper precautions are taken. In the case of cabbages grown in

gardens, all diseased plants should be either burned or deeply buried, and not given to pigs, etc., or thrown on the manure heap.

Again, it must be remembered, that land having produced a diseased crop is certain to be infected, and furthermore the parasite present in the soil retains its vitality for five or more years, unless treated with lime, hence the removal of such infected soil to other fields and portions of land on the wheels of carts, or on various implements, boots, etc., should be guarded against as far as practicable. A proper rotation of crops checks the disease, as does the removal of all cruciferous weeds, charlock, etc., on which the parasite may sustain itself during the interval between turnip crops.

Board of Agric. Leaflet, No. 77 (1902).
Eycleshymer, *Journ. Mycol.*, 8, p. 79.
Halsted, *Amer. Gard.*, 19, p. 375.
Massee, *Proc. Roy. Soc.*, 57 (1895).
Nawaschin, S., *Flora*, 86, p. 404 (1899).
Ward, M., *Diseases of Plants*, p. 47.
Woronin, *Pringsh. Jahrb.*, 11 (1878).

Crown gall.—This disease, caused by *Dendrophagus globosus* (Toumey), is reckoned as a serious disease in some parts of the United States. It is considered probable that it is identical with the disease known in Germany and some other European countries as wurzelkropf, but this is not definitely proved. It has not been recorded in this country. The injury results in the formation of swellings at the crown of the root, and also on the smaller roots. The swellings are at first small, but gradually increase in size until they attain the dimensions of a cricket-ball, or in some instances much larger. All kinds of fruit-trees, also the vine, are liable to attack. The plasmodium of the fungus lives in the substance of the gall, and under favourable conditions comes to the surface, where it forms deep orange, sessile, globose sporangia, about 1 mm. diameter; spores globose, orange-yellow, 1·5-3 μ diam., capillitium scanty.

The disease is spread by infected nurseries sending trees into different parts of the country, also by diseased trees being distributed for firewood.

Toumey's suggested remedies are as follows:

So little is as yet known regarding this disease, that few systematic attempts have been made to treat it by the

application of fungicides. My own experiments and those of Selby, prove conclusively that sulphur is of no value whatever. Bluestone, when of sufficient strength, appears from the evidence that we now have, to be of material value, and when mixed with copperas and lime it is the best of all materials yet experimented with. Although in all my experiments with the paste previously described, copperas was one of the ingredients used, I believe that bluestone and lime made into a paste will be found equally effective. Lime is recognised as the most effective remedy known in treating, or rather preventing 'club-root,' a well-known and somewhat similar disease of cabbage.

From the position and character of the disease, it is evident that no remedy will completely overcome it after the orchard is once attacked. The best that can be done will be to keep the galls from forming on the crowns of the trees, where they do the greatest damage. The galls which form deep down on the lateral roots are of little moment compared with those which come at the crown; hence, if an orchard be examined yearly and all the galls cut from the crowns, and the wounds covered with the bluestone-copperas-lime paste, there is no reason why a badly infected orchard should not live and fruit for many years. It is not reasonable, however, to expect that the trees will do as well and fruit as abundantly as trees with perfect root systems.

Toumey, J. W., *Univ. of Arizona Agric. Expt. Sta.*, *Bull.* No. 33 (1900).

Corky scab of potato is due to the ravages of one of the Myxogastres called *Sponogospora scabies* (Mass.). This pest was first described by Berkeley more than half a century ago, under the name of *Tuburcinia scabies*. This was afterwards changed to *Sorosporium scabies* by Fischer de Waldheim. Both these observers considered the fungus as belonging to the Ustilagineae or 'Smuts,' on account of the spores being produced in clusters or spore-balls. Finally Brunchorst carefully studied the disease in Norway, where it is very prevalent, and discovered that the organism was not a fungus, but a member of the Myxogastres or Mycetozoa, and being unaware of the fact that it had been previously described by Berkeley, called it *Spongospora solani*. Some people profess to trace the name back with certainty to much older authors, on the strength of retrospective synonymy, but Berkeley's

description and figure is the oldest, that enables any one to be certain as to the fungus he had in view.

The action of the parasite on a potato tuber is very varied. Sometimes a considerable number of small, more or less circular, superficial scabs are formed, as in the accompanying illustration. In other instances more or less extensive

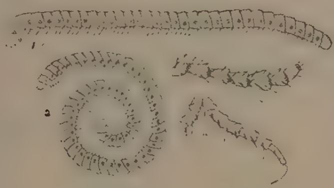

FIG. 158.—*Julus pulchellus.* A millipede that frequently damages potato tubers; mag.

cavities are formed, which become lined with a dense mass of snuff-coloured powder, consisting of spore-balls. These cavities are sometimes quite large, and are frequently augmented in size by *Julus pulchellus*, which is often present in great numbers, so that eventually the potato becomes hollowed out. In other cases the *Sorosporium* causes the formation of large, projecting, more or less truncate outgrowths, which might at first sight be mistaken for 'black scab.'

The plasmodium of *Sorosporium* may be seen in the cells of the potato just below the surface of the scab, and gradually encroaches on the sound portion of the potato by passing from one cell to another, the older or most superficial portions of the plasmodium becoming gradually transformed into spore-balls.

The plasmodium appears to be only active during the period when the tuber is growing, and passes into a resting condition when the tuber is dormant during the winter. In the spring, when the potato commences to sprout, the plasmodium again becomes active and migrates from the old tuber or 'set' into the new tubers formed during the process of growth. By such means the parasite passes from one generation of potato tubers to another without leaving the host. Many of the spore-balls produced by a diseased crop pass into the soil, and it has been shown that land containing

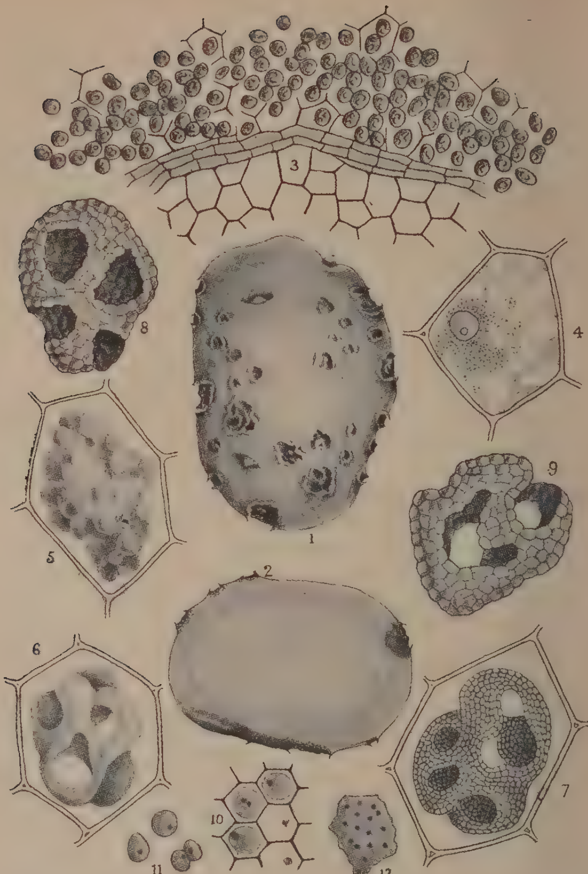

FIG. 159.—*Spongospora scabies*. 1, tuber showing wounds made during early development of the parasite; 2, section of same potato; 3, mature spore-balls of *Spongospora*; 4, amoeboid bodies of *Spongospora* in a potato cell, the starch has already disappeared; 5, showing the amoeboid bodies fused to form a plasmodium in a potato cell; 6, a more advanced stage of the plasmodium; 7, the plasmodium in a still more advanced stage, showing its substance broken up into a layer of spores forming a 'spore-ball'; 8 and 9, free spore-balls that have escaped from the cells of the potato; 10, cells forming a spore-ball; 11, amoeboid bodies that have escaped from the cells of a spore-ball; 12, portion of plasmodium showing nuclei. Figs. 1 and 2 nat. size; the remainder highly mag.

such spore-balls yields a diseased crop, proving that the spore-balls retain their vitality in the land for at least one season, and are capable of infecting young potatoes.

The aggregations of spores, or spore-balls, each of which is the outcome of the conversion of the mass of plasmodium contained in a single cell of the potato tuber into a mass of spores, are irregularly globose or elliptical in shape, and vary from 40 to 50 μ in diameter. The component spores are globose, and vary from 3·5-4 μ in diameter.

The origin of the spore-balls is briefly as follows: The plasmodium first appears in the cells of the potato under the form of minute amoeboid bodies, capable of independent movement. These amoeboid bodies soon coalesce to form a compact mass, or plasmodium. This plasmodium, after remaining in a vegetative condition for some time, during which the contents of the host-cell, starch, protoplasm, and nucleus, have been used as food, becomes frothy and vacuolate. Finally the plasmodium becomes distended into a thin film by the formation of a large central vacuole, the thin film or wall becoming pierced here and there by irregular holes. When this stage is reached the outer wall of plasmodium becomes simultaneously converted into a layer of cells or spores, thus the mature spore-ball consists of a single layer of closely compacted spores, broken here and there by irregularly shaped holes, surrounding a central cavity.

This disease is rampant in the west of Ireland, not uncommon in Scotland and the north of England, but is rare in the south. It is also common in several continental countries.

As the parasite hibernates in the tubers, it is important that those showing signs of infection should not be used for 'sets.' I know it has been stated that if diseased tubers are treated with formalin, the parasite is killed, and such tubers may be planted with safety. This statement, although made by myself some years ago, I am now very much inclined to doubt. The superficial plasmodium may be killed by such treatment, but the deeper-lying portion would certainly escape injury.

Infected land should be dressed with *quicklime*, preferably in the spring, when the spore-balls are germinating in the soil. As *Spongospora* is not known to attack any other kind of

cultivated plant than potatoes, alternation of crops is suggested.

Berkeley, M. J., *Journ. Hort. Soc.*, 1, p. 9, pl. 4 (1846).
Berkeley, M. J., *Ann. Mag. Hist.*, June, 1850, p. 26.
Brunchorst, A., *Bergens Museums Aarsberetn*, 1886, p. 219.
Fischer de Waldheim, A., *Aperçu systematique des Ustilaginées* (1887).
Johnson, T., *Economic Proc. Roy. Dublin Soc.*, 1, p. 453 (1908).
Massee, Geo., *Journ. Bd. Agric.*, p. 592, 1 pl. (1908).

FIG. 160.—*Spumaria alba*. The plasmodium has crept up the stems of a grass, to mature its spores. Reduced.

Sorosphaera veronicae (Schröt.) forms small, irregular, or cylindrical outgrowths on the leaves of various species of

Speedwell (*Veronica*). The galls contain numerous spore-balls, each enclosed in a delicate membrane, and consisting of a single layer of elliptical spores enclosing a central cavity. The individual spores measure 8-9 × 4-4·5 μ.

Tetramyxa parasitica (Goeb.) forms little swellings on stalks, leaves, and flowers of *Ruppia rostellata*. The multinucleate plasmodium breaks up into small portions, each containing a nucleus. These portions afterwards divide into four spores, each containing a nucleus. The four spores remain joined together, enclosed in a delicate membrane.

Spumaria alba (D C.) sometimes proves indirectly injurious; its plasmodium often creeps up the stems of living grasses, and forms spore-masses up to 2-3 inches in length and an inch in diameter. These are at first covered with a white crust, which soon falls away, exposing the soot-like mass of spores, which are globose, minutely warted, dusky purple or brownish, 10-13 μ diameter.

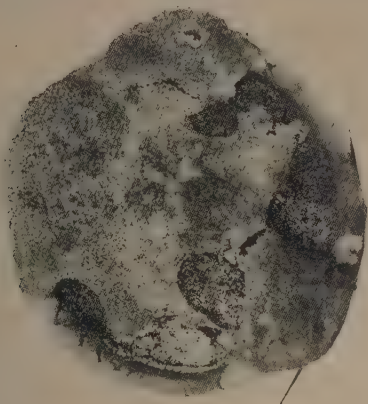

FIG. 161.—*Fuligo varians*. The plasmodium has crept over the soil in a plant-pot, and formed its mass of spores, which are covered with a yellow crust of lime. Reduced.

When produced in considerable quantity, the dense masses of spores are said to injure vegetation by a process of suffocation. It is not a parasite.

Instances are also on record where horses and other

animals have suffered, or even died from the effects of having eaten the masses of spores adhering to grass, etc. In such cases the injury is caused by the irritating action of the spores on the mucous membrane. No active poison is present.

Flowers of tan (*Fuligo varians*, Rost.) forms large crust-like patches, usually of a canary-yellow colour, or sometimes whitish, on tan in greenhouses, on heaps of dead leaves, etc. Sometimes the plasmodium creeps over seedlings which it envelops and suffocates, or it may creep up the side of a plant-pot and form its fruit on the soil. The spore-mass under the crust is blackish-brown and powdery when mature and dry. Spores globose, pale lilac-brown, smooth, 7-11 μ diameter. Not a parasite.

INJURIES CAUSED BY ANIMALS AND BIRDS

It is not intended in this place to discuss the numerous injuries to plants caused by animals and birds, which directly result in the death of the plant attacked, as when the stem is gnawed through, or when a prospective crop is lost, owing to mice or birds devouring the seed. There are many instances, however, where the injury done is not sufficient to cause the death of the plant directly, yet the wounds made frequently enable fungi, insects, rain, etc., to gain an entrance into the living tissues. Among such may be enumerated the barking of trees by game, mice, etc., and the holes made in tree trunks by woodpeckers.

The rabbit (*Lepus cuniculus*) often causes serious injury to young trees, especially during the winter months, by nibbling away the bark near the collar, the object being to satisfy hunger.

Various preparations are on the market for smearing on the stem to prevent such injury, but all such are liable to injure the bark, notwithstanding statements to the contrary; wire netting, although somewhat expensive, is a certain safeguard.

The squirrel (*Sciurus vulgaris*) undoubtedly does considerable damage to trees. A great deal of sentiment is brought to bear on the question as to the destruction of so universal a favourite, nevertheless, according to the evidence of foresters, an immense amount of injury is done by squirrels to seedling and young conifers. Birch and ash also suffer, the bark being pulled off all round or torn off

in long strips. In birch woods the trunks are often completely barked from top to bottom. Squirrels also eat fruit. On the other hand squirrels do a certain amount of good by destroying some destructive insects, lardae of beetles, etc.

The suggestion offered as a remedy is that they should not be allowed to become numerous, as they are in many woods.

Chapman, A., *Trans. Roy. Scot. Arbor. Soc.*, 17, p. 161 (1903), and p. 12 in Append. (1904).

A writer in *Journ. Hort.*, June 10, 1909, says: 'The squirrel likewise displays its sportiveness to advantage in springtime, not failing to find its store of acorns and Spanish chestnuts laid up in the previous autumn, displaying considerable power of memory, an attribute usually regarded as the prerogative of man. It also "smells" the germinating nuts or seeds sown in nurseries, and not least of its antics is guiltiness of attacking the young of useful birds. Its feeding propensities are displayed in woods, parks, plantations, and pleasure grounds by devouring the buds of trees, usually flowering trees; and later on it takes to the young growths, and precludes all prospect of profitable timber production. Yet these creatures are taken under the protecting arms of the "lover of nature," in blissful ignorance that if afforestation in this country is to be successful the squirrel must go, and all the Rodentia.'

Voles, although amongst the most injurious of our rodents to different forms of plant life, are commonly confused with rats, mice, and shrews. The Water Vole (*Microtus amphibius*) is known as the Water Rat, and the Field Vole (*Microtus agrestis*) is considered in ordinary parlance as a mouse. The Bank Vole (*Evotomys glareolus*) is also considered as a mouse or a shrew. The voles are distinguished from rats and mice by the stout body, thicker head, blunt muzzle, by the very short ears which are almost or completely buried in the fur, and the comparatively short tail. All three species injure plants, more especially the roots of grass, etc., but they also do considerable damage to trees by eating the buds and barking exposed roots and base of trunks of trees. Every now and again the Field Vole appears in enormous numbers and a general epidemic is the result, everything in the way of a plant being indiscriminately destroyed. One such epidemic was experienced in the south of Scotland in

the year 1891, which resulted in the destruction of pastures, heather, trees, and practically everything of a vegetable nature that was encountered. According to Theobold this plague was the outcome of 'constant war with trap and gun upon the gamekeeper's so-called "vermin."' The Scottish farmers had to suffer for the ignorance of the gamekeepers, who had killed off the natural enemies of the voles—namely, the hawks, owls, crows, weasels, polecats, etc.—which even in game preservation do more good than harm, as we have seen in the fatal 'grouse disease.'

A still more serious outbreak of voles occurred in Thessaly in 1892, which threatened to destroy the whole corn crop of the district; but thanks to Professor Loeffler, the voles were exterminated by inoculation on a large scale with his bacilli *typhi murians*.'

Voles often nibble quite through living roots of beech and other trees. I have seen roots two inches in diameter cut completely through, and it is stated that roots as thick as a man's arm are often similarly treated.

Theobold, F. V., *Agric. Zoology*, p. 471 (1899).

Mice are mischievous little animals that often do a certain amount of damage to trees, the vine being a special favourite. The Field Mouse (*Mus sylvaticus*) is a terror in the garden, ruining bulbs and clearing out rows of peas, etc.

When the bark of plants has been injured, the wounded part should be wrapped round with old flannel soaked in puddled loam, when new roots will be formed if the bandage is kept moist. It may be mentioned, although outside the scope of this work, that if a layer of sifted coal ashes about an inch thick is placed over rows of newly sown peas, they are protected from raids by mice.

Woodpeckers are guilty of injuring trees to a certain extent by making holes in the trunk in which they build their nests. Sound as well as partly decayed trees are used for this purpose, soft-wooded kinds being preferred.

The Green Woodpecker (*Gecinus viridis*), Greater Spotted Woodpecker (*Picus major*) and Lesser Spotted Woodpecker (*Picus medius*) are our commonest species.

On the whole, the good done by these birds in feeding on injurious insects more than compensates for any injury done. The holes made should be filled with cement to prevent the entrance of wet or the spores of fungi.

MITES

The mites belong to the Acarina, an order included in the class Arachnida, and are related to the scorpions, spiders, cattle ticks, etc. Some species are parasitic upon animals, others upon plants. The latter are included in the group Eriophyidae, all the members of which are very minute, ranging between $\frac{1}{250}$ and $\frac{1}{80}$ of an inch in length, hence they are hardly visible to the naked eye. The mites are almost colourless, worm-shaped, and composed of two distinct parts.

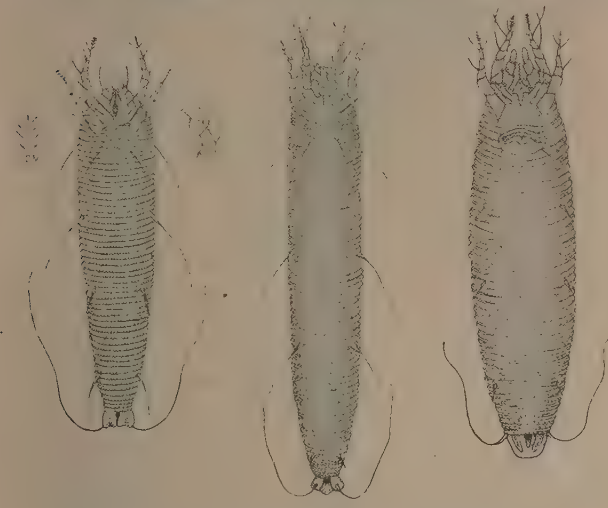

FIG. 162.—Left-hand fig., *Eriophyes ribis*, the black currant bud mite. Middle fig., *Eriophyes vitis*, the vine leaf mite. Right-hand fig., *Eriophyes avellanae*, the hazel bud mite. All highly mag.

The anterior part is broad and short, and consists of the head and thorax fused together, constituting the cephalo thorax; the posterior portion or abdomen is elongated and tapering, and delicately transversely striated. Two pairs of legs are borne close to the rostrum.

In addition to the species of economic importance, many mites form galls on our wild plants.

Black currant gall mite.—This disease of black currants,

caused by *Eriophyes ribis* (Nalepa), sometimes known as 'big bud,' is unfortunately too well known to require a detailed description. Diseased buds are known by their large size, globular form, and in remaining on the tree for a considerable

FIG. 163.—*Eriophyes ribis*, causing 'big bud' of black currant.

time in an unexpanded condition—in fact they are killed by the mites, which are often present in thousands. During early summer most of the mites leave the old dead buds and migrate to the newly formed buds, where they remain for

another season. The life-history of these minute organisms, which are not quite $\frac{1}{300}$ inch in length, is but imperfectly known.

The mites are readily dispersed by wind, insects, clothing of persons moving amongst the bushes, and more especially by using diseased portions of plants for propagation. By such means new areas of infection are established.

Unfortunately no certain cure is known. Picking by hand of the infected buds is the most effective preventive method; the swollen infected buds should be burned. Theobold says that from repeated observations he has found that the bud above and the bud below an infected one contains mites, and that these should be removed along with the infected one. The same authority states that cuttings can be safely disinfected by immersing them in water for some days before setting. Cold water has been found quite successful if left in it for a couple of days. A better treatment was found by Pickering, namely, of immersing the material in water at 115° F., for ten minutes before planting.

Some years ago I conducted some experiments at Wisley, for the purpose of devising some method for the extermination of the 'big bud' mite, and found that covering the branches of a badly infected bush with grease or vaseline effected this object. Not being in the same rut as those dealing with mites, the suggestion of such an idea brought down a whirlpool of indignation accompanied by ridicule; nevertheless it answered the purpose when tried by unbiassed minds.

The procedure is briefly as follows, based on the facts that the mites migrate from the old, dead, infected buds to newer parts of the bush during late spring and early summer, and that the said mites become entrapped and held fast when they attempt to walk on a greasy surface. The shoots of infected bushes should be coated with cart grease or some similarly sticky substance, applied with a brush. The diseased buds need not be picked off, as when they are coated with grease the mites cannot escape. A fuller account of the process, with replies to criticisms, will be found in *Journ. Roy. Hort. Soc.*, 38, p. 163 (1907).

Collinge, W., *Rep. Injurious Insects and other Animals in Midland Counties*, p. 6, 1904.

Lewis, E. J., *Journ. S. E. Agric. Coll.*, No. 11, p. 55-80 (1902).

Theobold, F. V., *Insects and Pests of Fruit Trees*, p. 231 (1909).

Nut gall mite (*Eriophyes avellanae*, Napela) sometimes proves destructive to cobnuts and filberts. It forms big buds similar to those made by the black currant mite, which either shrivel and die or expand into a mass of deformed, stunted leaves. Such buds are very conspicuous on the bushes in winter.

The belief is current in some districts that the nut mite and the black currant mite are the same species, and that the nut mite can infect the black currant, and *vice versâ*. This idea is a mistaken one; the two mites are distinct species, and each one can only infect its own host-plant. However, prejudices die hard, and an object lesson was considered to be the only means of convincing sceptics. With this object in view, I had a long row of badly-galled 'Baldwin' black currant bushes planted in the experimental ground at Wisley, and alternating with the currant bushes, perfectly clean hazel bushes were planted. The bushes were intentionally crowded so that the branches of nut and currant were in contact. This row remained growing for some years, but the hazels remained perfectly free from disease. On the other hand, black currant bushes, free from 'big bud,' were planted in close proximity to diseased hazel bushes. The currant bushes remained free from disease. Sceptics were not convinced.

Pear leaf blister mite (*Eriophyes piri*, Nal.) is a well-known pest in Europe and the United States. In this country the pear is more especially attacked, the apple rarely, but in the United States the apple suffers more severely than the pear. Among other hosts of the parasite are the service berry (*Amelanchier vulgaris*); cotoneaster (*Cotoneaster vulgaris*); white beam (*Sorbus aria*); mountain ash (*Sorbus ancuparia*); service tree (*Sorbus terminalis*).

On pear leaves and young fruit the mite at first forms minute greenish warts or blisters, which as a rule soon change to a red colour, and at a later stage become brown or black. When the minute galls are numerous they often coalesce and form diffused red, then black patches; in such cases the leaves fall early in the season. The mites hibernate in winter in the buds, and as the leaves expand the mites emerge from the galls and enter other points of the same or other leaves through the stomata, and thus the disease spreads until near the end of the growing season. When the leaves become old the mites migrate and enter the newly-formed buds, where they remain until the following spring.

Theobold says that there is no doubt that this pest is spread with nursery stock; it is therefore essential that it should be fumigated with hydrocyanic gas when in a dormant condition.

Hand-picking the leaves is a very effective method of eradicating the pest, and should not be delayed later than June.

Parrott, Hodgkiss, and Schoene state that the mite was held in check on pear-trees by spraying with self-boiled lime-sulphur wash, prepared as follows:—Lime 30 pounds, sulphur 15 pounds, and caustic soda 5 pounds, to 50 gallons of water. Better results followed spraying in December than in April.

Theobold, F. V., *Insects and Pests of Fruit Trees*, p. 353 (1909).

Vine erinosis.—This disease is caused by *Eriophyes vitis* (Landois). Numerous, small, irregularly shaped spots appear on the leaves, concave on the under and convex on the upper surface of the leaf; the concave side of each spot is densely velvety, pure white at first, gradually changing to a rusty-brown colour. I examined an old vine growing on a wall forming the face of a moat, not far from Reading, that had every leaf attacked, and as the spots were in the white stage, the effect was very striking. Mites were present in abundance in the buds of this vine on the 20th January, and thus it appears that they hibernate in the buds, and do not leave the tree.

The young shoots, tendrils, floral peduncle, and parts of the flower are also attacked.

Viala, *Les Maladies de la Vigne*, Ed. 3, p. 570 (1903).

Birch mite (*Eriophyes rudis*, Nal.) not infrequently arrests the growth of the common birch, by arresting the development of the leaf-buds. When a bud is attacked, many other buds develop on the branch in close proximity to the infected one. These in turn are infected, the result being a compact cluster of buds that do not develop further. Where the disease is of old standing the majority of branches on a tree bear numerous clusters of such diseased buds, which alters the entire aspect of the tree, and prevents the formation of the long slender branches characteristic of this tree.

The disease appears to extend at a very slow rate. I have for the past fourteen years observed a tree badly infected

that is surrounded by several other birches, many of which remain perfectly free from disease, while others show a few scattered tufts only of infected buds.

Eriophyes nervisequus (Can.) forms minutely velvety patches, consisting of crowded, more or less irregularly club-shaped hairs, on the under surface of living beech leaves. These patches are sometimes of a beautiful crimson colour, more frequently reddish brown, and sometimes greenish. Some-

FIG. 164.—*Eriophyes rudis*, causing arrest and galling of buds of *Betula alba*.

times narrow lines of these hairs follow the larger veins on the upper surface of the leaf. These velvety islands are by no means uncommon on the upper or under surface of living leaves belonging to various kinds of plants, and were at one time considered as fungi, and included under the genus *Erineum* (Pers.).

Eriophyes kerneri (Nal.) is recorded as being the cause of galled gentian flowers (*Gentiana campestris*, L.) in Scotland. The flowers remain closed but much swollen and distorted,

the stamens often having no pollen. The ovary becomes inflated, and, bursting down one side, displays a smaller flower of like structure, the ovary of which may even show a third flower from its interior.

Trail, J. W. H., *Ann. Scot. Nat. Hist.*, 1907, p. 252.

Eriophyes stenaspis (Nal.) forms a very characteristic gall on living beech leaves, the margin of the leaf being rolled up into a narrow tube, more or less filled with hairs.

The pink tea mite (*Phytoptus theae*, Watt).—According to Sir George Watt, by whom the mite was first discovered, the tea plant suffers very severely in Assam, Cachar, Darjeeling, and Duars. The characteristics of the disease are very pale-coloured leaves, almost white, dry, convex above, with the margins and veins of a pink colour. In an advanced stage of disease the leaves are almost bronzed, from the extension of the pink tinge over the larger portion of the leaves, but they did not wither and fall off the bush. Under a pocket-lens it is seen that the pink tinge is due to the presence of myriads of very minute pink mites. The adult mite is about 1/00 of an inch long, linear-oblong, broadest near the head and gradually tapering to the tail. In walking the head is carried at a higher level than the tail, which is furnished with a sucker-like arrangement.

The immature mites are more elliptic in shape and taper at both extremities. At first they are pure white and hyaline, and only assume a pink colour after having moulted twice.

The pink mite is hardly, if at all, found on the China tea plant, and less on the Manipurijat than on the Assam indigenous. It occurs on rich plateau lands, and like other mites prevails to a greater extent during dry seasons than in wet weather, but is not washed off the bushes at all easily, as if a fortnight's dry weather occurs in the middle of the rains it is again present and doing damage.

Bordeaux mixture is the best treatment, and should be applied immediately after pruning. The cost is amply repaid in a single season. Sulphur is also effective if it can be got on the under surface of the leaves.

Watt, Sir George, and Mann, H. H., *The Pests and Blights of the Tea Plant*, Ed. 2 (1903).

The five-ribbed tea mite (*Phytoptus carinatus*, Green), known also as the 'purple and white mite,' was first observed

by Green in Ceylon, in nurseries and also on plants on tea estates generally. It was afterwards observed in Assam and in India, doing considerable damage to the tea plant. The effect of this mite is to give a bronze appearance to the foliage, as if sunburnt, but they retain their shape. June seems to be the worst month for its attacks. At this time the affected leaves fall off the bushes wholesale; the result is an immediate decrease of leaf; the bush is checked in development, and a so called hide-bound condition results, necessitating heavy pruning at an earlier date than otherwise necessary. The young mites, which are very minute, are greenish semi-transparent, pear-shaped, tapering to a point behind. The adult mite is a dull purple-coloured insect, with five white ridges of a waxy material running along the back, and a similar ridge surrounds an hour-glass-shaped space in front of the body.

One part of kerosine emulsion in eighty parts of water, or one of phenyl (carbolic acid) in two hundred and forty parts of water is recommended. The nurseries should be watered with the mixture in the evening, and with pure water on the following morning, unless rain should have fallen during the night.

Plants removed from the nursery for planting should be dipped in the mixture. The stem and leaves only should be dipped, not the roots.

Watt, Sir George, and Mann, H. H., *The Pests and Blights of the Tea Plant*, Ed. 2 (1903).

Tea mites.—Much valuable information respecting mites that injure the tea plant in India and Ceylon is contained in the following work.

Green, E E., *Roy. Bot. Gard. Ceylon*, Circular Ser. 1, No. 17 (1900).

Cecidophyes schmardae (Nal.). This mite causes an abnormal growth of the whole or part of the inflorescence of *Campanula glomerata* and *C. rapunculoides*, which results in the production of what is termed virescence, the flowers being replaced by hairy, distorted, green structures.

Bulb mite (*Rhizoglyphus echinopus*, Michael), also known as the 'Eucharis mite' or 'Bulb mite,' attacks bulbs and tubers of various kinds, as tulip, lily, hyacinth, onions, eucharis, potato, dahlia, etc. It has also proved destructive

to the roots of the vine. This mite has been distributed all over the world in its food plants.

The indications of its presence are: arrest of growth; the leaves becoming yellow; failure to produce flowers; reddish-brown spots on the bulb-scales, indicating places where the mites have been feeding.

There was at one time some difference of opinion as to whether the mite was the primary cause of injury to the bulbs infested with it. It was thought that the injury might be due

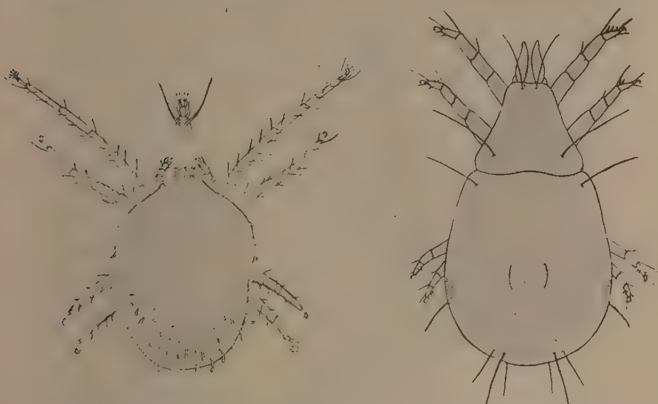

FIG. 165.—Left-hand fig., gooseberry red spider (*Bryobia ribis*, Thomas). Right-hand fig., eucharis mite, bulb mite, etc. (*rhizoglyphus echinopus*).

in the first instance to some error of treatment, and that the mites were simply feeding on the more or less decayed portions. It has, however, been definitely proved by Michael that the mites are the primary cause of injury, and that indeed they prefer sound bulbs. The base of the bulb and the roots are most frequently attacked, and the mites can often be seen in large numbers in the injured 'cushion' of the bulb when a magnifying-glass is used. The mites are very minute, sometimes not more than one-twentieth of an inch in length; they are yellowish-white in colour, with just a suffusion of pink, the legs and rostrum are red.

The following remedial measures are given in Leaflet No. 136, *Board of Agriculture and Fisheries*:—

1. This pest is very difficult to combat because the extremely

tiny mites feed not only on the outside of the bulbs, but they exist between the leaf scales of the bulb, feeding and laying their eggs in the interior, where they can scarcely be reached. The best plan is to burn infested bulbs, and the soil whence these have been removed should be disinfected.

2. Wash or spray the bulbs with paraffin, the treatment being repeated a fortnight later.

3. Wash the bulbs in sulphide of potassium (liver of sulphur), 1 oz. to 3 gallons of water, or brush with this after

FIG. 166.—*Rhizoglyphus echinopus*, the 'bulb mite'; has destroyed the roots of a *Hippeastrum* bulb.

removal of the outside loose scale leaves. This treatment is useful against fungi which follow the attack of the mite.

4. Fumigate with bisulphide of carbon. The bulbs to be treated should be placed in an air-tight receptacle, and a saucer, into which bisulphide of carbon has been poured, placed on the top of them. The bulbs should be left in the vapour for forty-eight hours. This treatment could be usefully extended to imported bulbs, which ought to be examined for the mite. The formula for fumigation on this larger scale is one pint of bisulphide of carbon to 1000 cubic feet of space.

Bisulphide of carbon fumes are very poisonous, and should not be breathed, and no naked light (the operator, for example, should not be smoking) must be brought near them.

Red spider.—Several mites are included under the general term 'red spider,' and judging from the literature on the subject, opinion is divided as to the number of species present in this country, and under what names they should be known. This, however, in the present instance is not of primary importance. The form so injurious to plants under glass is called *Tetranychus telarius*, which spins a delicate web on the under surface of leaves, etc. Leaves that are attacked soon present a mottled yellowish appearance, and finally fall. A dry, warm atmosphere favours the extension of the mite. Syringing with a solution of potassium sulphide holds the mites in check, if begun sufficiently early, but if the webs are allowed to be fully formed, spraying is of little avail. Under such circumstances the fumes of sulphur should be resorted to as the best means of destroying the mites.

Hydrocyanic acid gas also destroys red spider.

Hops, melons, and cucumber are amongst outdoor plants that suffer severely from the attacks of species of red spider.

Gooseberry red spider.—This mite often does serious injury to gooseberry bushes by sucking the sap from the leaves, which consequently results in early defoliation, the fruit also frequently falling prematurely. Infested leaves are speckled with ashy-grey, or altogether assume a leaden tinge. The mite is known as *Bryobia ribis* (Thomas), and is distinguished from the red spider of the vine, etc. (*Tetranychus telarius*), by its larger size, and by the first pair of legs being much longer than the rest. The colour varies from dull red to grey or greenish. It does not spin a web. Like the other kinds of red spider, this species is generally considered to be favoured in its development and extension by dry, warm weather, nevertheless during the remarkably wet season of 1909 the gooseberry red spider was received in exceptional quantity from different parts of the country at Kew for identification.

Spraying thoroughly, as occasion requires, with a solution of potassium sulphide is of service in checking the spread of the mites.

A fuller account of this and other mites attacking fruit-trees will be found in Theobold's excellent book on *The Insect and other Allied Pests of Orchard, Bush, and Hothouse Fruits.*

Red spider of the tea plant (*Tetranychus bioculatus*, Wood-Mason) is a pest that causes serious injury to the tea plant in all districts in India. The symptoms indicating the presence of this pest are a mottled dark and light green appearance of the leaves; in time the punctured portions turn brown and the leaves assume a bronzed, dry, crumpled appearance, and when badly injured fall off the bushes. Red spider is essentially a spring pest, in other words, of the hot, dry months. It first appears on the old leaves at the circumference of the bush, but gradually ascends and invades the whole bush. It often commences near the coolie lines, and spreads along the roadsides, or accompanies the main, open, and dry drains, and in such a manner as to suggest that it may be distributed by the clothes of the coolies. Bushes are most affected where the soil is in poor condition. An attack of red spider does not immediately affect the existing flush, as the insect only feeds on the older leaves, but from the constant loss of sap; the leaves become dry and curled, and in bad cases of attack fall off, thus weakening the whole tree. The pest is most injurious in dry weather, and is unable to withstand continued heavy rain.

The prevailing tint of the mite is scarlet; the eggs are laid in sheltered spots on the upper surface of the leaf, near the mid-rib or alongside the veins. The males are considerably smaller than the females, and pointed at the anal extremity. The upper surface of the leaf is enveloped in a fine web that is rendered visible in the early morning through the coating of dew upon it.

Dusting with sulphur when the bushes are wet has proved to be the most effective remedy. This only kills the mites, and should be repeated as the eggs hatch out.

Watt, Sir George, and Mann, H. H., *The Pests and Blights of the Tea Plant*, Ed. 2 (1903).

EELWORMS

The eelworms or nematode worms belong to the group Vermes or worms proper. The few species that prove injurious to plants are very minute, scarcely or not at all visible to the naked eye, almost colourless, and, as their popular name denotes, resemble miniature eels in form and in their wriggling movements when seen under the microscope. The majority of nematodes parasitic on plants form swellings

or galls on the part attacked, and largest when the root is the part selected. Such galls vary much in size in different species of plants. In a specimen of *Impatiens Oliveri*, growing in the temperate house at Kew, many hundreds of galls, varying in size from a marble to that of a walnut, were present on the root, caused by *Heterodera radicicola* (Nal.). On the roots of tomatoes, cucumbers, etc., the knots or galls are usually less than half an inch in diameter, whereas, so far as I have observed, on the roots of vines, clover, etc., the galls formed by the same organism are yet smaller.

Eelworms are almost universally considered as doing a great amount of injury to cultivated plants, and in all probability such is the case, yet I have often wondered whether they are always the primary cause of mischief. Experience has taught me to always look for fungus mycelium when I cut an eelworm gall, and I am rarely disappointed. When such fungus is grown out it proves to be a species of *Fusarium* or *Fusoma*.

The following is a recapitulation of the life history of Heterodera, and the formation of its galls, as given by Stone and Smith in their excellent treatise on Nematode Worms:

'Young worms coming into the soil from previously affected plants wander about until they find roots suitable for their attacks. Aided by a spear-like organ in the head they force their way into the younger portion of the root and embed themselves in its tissue. This irritation of the tissues of the plant causes an abnormal development of the root, consisting in an increased production of cells, and a derangement of the tissues from their natural arrangement. The worms increase in length and much more in diameter, assuming a spindle and then a club shape. The females continue this swelling process until they have the shape of a gourd and a size just visible to the eye. They are now mature, and having been fertilised by the male previous to their maturity they produce eggs which develop into the young worms of the next generation. The life period of the female is about six weeks. The male worms do not remain in the swollen form, but about after four weeks from entering the root they change again into a slender worm-like form which enables them to move about and seek the females, with which they copulate and then perish. While the worms are developing, the abnormal growth of the root continues and results in a gall-like swelling or enlargement and such a disarrangement of the tissues that the progress of the sap through the plant is hindered to an

extent depending on the number of galls on the roots. This injury, together with that caused by the worms drawing their food from the plant, checks its growth and often kills it outright, or so weakens it that fungus diseases come in and hasten its destruction.'

The same authors state that 'the most effectual, complete,

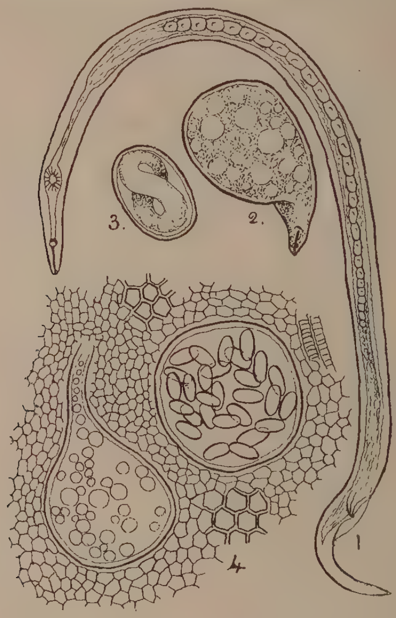

FIG. 167.—Eelworms. 1, male of *Tylenchus devastatrix* (after Ritzema Bos); 2, female of *Heterodera radicicola*; 3, egg of same; 4, section of portion of a tomato root, showing two females of *Heterodera radicicola* in section, one of which contains numerous eggs.

and practical method at the present time of exterminating nematodes in greenhouses is by heating the soil by means of steam. This can be accomplished without much expense, providing proper attention is paid to the method of applying the steam.

'A pressure of steam exceeding 50 lbs. is not only cheaper but more effective than a pressure which falls below this, and the amount and cross section area of the tile is important. The cost of heating soil depends upon the equipment employed and cost of labour, etc. Probably not far from 100 cu. ft. of soil under the most favourable conditions can be heated in one hour's time to a temperature of over 200° F.

'The minimum amount of heat necessary to kill nematodes and their eggs while confined to the soil is about 140° F., but for all practical purposes it is desirable to make use of a higher temperature, at least from 180-212° F.

'The benefit of steaming and sterilising the soil is not alone confined to the destruction of nematodes. Many other greenhouse pests are killed. The mechanical conditions of the soil are moreover greatly improved, the humus compounds are rendered more available for plant food, which results in giving plants grown in sterilised soil a considerable acceleration in their rate of growth.

'The changes of the environment which appear to affect Heterodera the most are freezing and dessication. Either of these agencies might be employed in certain cases to kill nematodes. The latter gives promise of becoming a cheap and efficient method.'

Sulphate of potash up to 3 cwt. per acre is recommended where eelworms are present in fields, as in the case of tulip-rooted oats, clover sickness, beetroot disease, etc.

Stone, G. E., and Smith, R. E., *Hatch Expt. Sta.*, *Mass. Agric. Coll.*, *Bull.* No. 55.

Eelworms attack many different kinds of plants. Kühn gives a list of 180 European plants belonging to fifty-three different families. This was in 1881, since which time the list has been greatly extended.

Root-knot disease in cucumbers and tomatoes (*Heterodera radicicola*) often seriously injures cucumbers and tomatoes by forming numerous knots or swellings on the root. These galls vary in size from that of a turnip seed to a marble, and are sometimes roughly globose, at others elongated. The general structure of the root is much modified by the action of the eelworms, and its power of conducting water is materially checked, consequently when the galls are present in abundance the root ceases

to perform its function of supplying water to the above-ground portion of the plant.

The following measures for sterilising soil and checking

FIG. 168.—*Heterodera radicicola* (eelworm), forming galls in tomato root; slightly reduced.

the disease, are recommended by the Board of Agriculture, in Leaflet No. 75.

1. To destroy these eelworms the soil must be thoroughly

saturated three times, at intervals of a fortnight, with a solution of one part of carbolic acid in twenty parts of water.

2. A second remedy consists in mixing the soil intimately with gas-lime.

In either case the soil so treated must remain for at least six weeks before it can be used.

3. When soil in a house is infested, it is safest to remove the whole and treat it outside; the interior of the house should then be thoroughly washed with a solution of one part of carbolic acid in eight parts of water.

4. Mixing naphthalene with infested soil has been recommended, and some fumigants which contain naphthalene as an important ingredient have been favourably reported on.

5. A very important and somewhat discouraging fact to bear in mind is that a very large number of plants in addition to the cucumber, marrow, and tomato, have been recorded as host-plants for *Heterodera radicicola*. Among them are cultivated cruciferous plants, red and crimson clover, black medick, peas and beans, lettuce, potatoes, beet, some grasses, some rosaceous and other fruit plants, and such weeds as the dandelion and the rib-grasses or plantains. The practical import of this on the possibilities of spread of the pest is evident.

6. In experiments conducted at Kew against another species of eelworm infesting clover it was found that the eelworms were destroyed by treating the diseased plants with sulphate of potash, the quantity used in the experiments being equal to 4 cwts. to the acre.

The following method of clearing the soil of eelworms is also recommended:

'Carbolic acid has proved very effectual, and the amount to be used is governed, not by the superficial area but by the cubic content of the soil, which can readily be roughly estimated in the case of a frame. Two ounces of carbolic acid per cubic foot of earth is generally sufficient to eradicate the pest.'

Journ. Roy. Agric. Soc. Engl., 68, p. 239 (1907).

The Tea eelworm (*Heterodera radicicola*) is said by Sir George Watt to be very destructive to the tea plant in various parts of India, 75,000 seedlings being killed on one estate alone. It has also been reported from Ceylon. Up to the

present seedling tea plants have alone been injured, but its presence has also been observed on the roots of old bushes. On seedlings, nodulose swellings are formed on the root just below the collar. One of the most serious points about the eelworm is the fact that in affected areas it attacks nearly all the weeds as well as the tea. It appears to be specially prevalent where villages and village gardens have previously existed. In a case investigated in Darjeeling the land had been under cultivation for a long period. Dirty land and neglected clearances are also just the places in which those weeds which are peculiarly susceptible to the disease will be likely to grow, and pass on the eelworm to the tea.

The most important preventive method is to rid the land of all weeds capable of providing the eelworm with food. This should be followed by planting a trap-crop of some plant the eelworm will readily attack, and removing such plants before the eelworms pass from the plants into the soil. The second method is to starve the eelworm by allowing the land to lie without a crop for a year, or by growing a crop not attacked by the pest. In the hills, buckwheat would answer this purpose. Complete success has also been claimed by drying out the surface soil by constant cultivation in the dry weather for a season.

Watt, Sir George, and Mann, H. H., *The Pests and Blights of the Tea Plant*, Ed. 2 (1903).

Eelworm disease of oaks.—A destructive epidemic of young oaks is recorded from France. The pest is *Heterodera radicicola* (Greef), which attacks the root more especially in the region where mycorhiza are present.

Ducomet, *Ann l'École nat. d'Agric. Rennes*, 1909, p, 47.

Eelworm disease of coffee.—A root disease of coffee has long been recognised in the coffee plantations in Brazil, although the true cause has only recently been determined. A similar disease has recently been recorded from Costa Rica, and I have reasons for suspecting its occurrence in other coffee-growing districts in the New World. The characteristic symptoms of its presence depend on the age of the tree. When the tree is fairly old the leaves on young shoots turn yellowish-green and shrivel, the young shoots also blacken and wilt. This condition of things may

continue for months before the tree eventually dies. On the other hand, in the case of trees from four to six years old, having an abundance of healthy, dark-green foliage, and laden with berries, no preliminary symptoms foreshadow the end, which is sudden. The tap-root suffers most, becoming much swollen and barrel-shaped, and covered with much thickened, rugged bark, sodden with water. The cork-cells of the bark become sac-like and much elongated radially, resembling the palisade tissue of a leaf. The eelworms are present in numbers in spaces between these abnormal cork-cells.

The smaller roots usually also bear a number of knots or galls containing eelworms.

Diseased trees show up very conspicuously, and the disease gradually extends from a centre as fresh trees are attacked. So far as experience goes, when a tree is once attacked it never recovers, hence diseased trees should be removed on the first indication of disease.

Treating the soil with bisulphide of carbon is the most certain remedy. This should be applied when diseased trees have been removed, and the treatment should extend well beyond the area of diseased trees.

Noack, Fritz von, *Zeitschr. Pflanzenkr.*, 8, p. 137.

Clover sickness.—This is a general term which covers more than one specific disease of clover. The clover sickness caused by a fungus has been already described. In the present instance the injury is caused by an eelworm (*Tylenchus devastatrix*). The symptoms are a yellowing and gradual dying down of the clover, usually in patches which gradually extend in area. If the injury is actually caused by eelworm, the branches of affected plants will be found to be much swollen and spongy in texture, and microscopic examination will reveal the presence of eelworms and their eggs in the swollen tissue. If diseased plants are allowed to decay on the land the eelworms pass into the soil and endanger future crops. When the diseased patches are small, it is wise to remove all the plants and burn them, afterwards dressing the land with sulphate of potash, at the rate of 4 cwt. per acre.

'Tulip-root' or 'Segging' of oats.—This disease is caused by *Tylenchus devastatrix*. The symptoms are the swollen appearance of the base of the stem, which is usually sur-

rounded by a number of stunted and distorted shoots. Diseased plants are checked in growth and remain stunted. Eelworms and their eggs are usually present in considerable numbers in the swollen parts.

FIG. 169.—*Tylenchus devastatrix*. Clover plant attacked by stem eelworm, showing thickened and flattened branches.

Deep ploughing and treating with sulphate of potash are recommended when the land has produced a diseased crop.

As the eelworm attacks many different kinds of plants, it is important to avoid growing a crop on land that is infected,

that is especially susceptible. Clover should not follow, neither should oats follow clover that has been subject to eelworm disease. Barley is practically safe to follow.

In oats the base of the stem is often somewhat swollen, when attacked by the frit fly (*Oscinis frit*, L.), but in this case the minute larva or the chrysalis may be found when the stem is split open. The chrysalis is brownish and not more that the eighth of an inch long. Somewhat similar symptoms are produced in wheat by a fly called *Hylemyia coarctata* (Fallen).

Strawberry root eelworm (*Tylenchus devastatrix*, Kühn), is stated by Theobold to cause great mortality amongst strawberries. The plants rot and decay at ground level. There are no marked symptoms as when plants are attacked by *Aphelenchus*; the plants simply rot away, the leaves are sometimes crinkled and deformed.

Dressings of lime and sulphate of potash are recommended. Diseased plants should be removed.

Theobold, F. V., *Insect Pests of Fruit*, p. 474 (1909).

'**Ear-cockles**' **of wheat** (*Tylenchus tritici*, Bastian) is sometimes responsible for a considerable amount of shortage in the wheat crop. The grain is the part attacked, and becomes changed into a roundish, purple-black body, somewhat smaller than a normal grain. As a rule almost every grain in the ear is attacked. If an infected grain is crushed and the contents examined under the microscope, myriads of eelworms will be seen, and even when the grains are fifty years old, and have been kept dry all the time, on the addition of water the eelworms will soon begin to wriggle about in a characteristic manner. This was at one time one of the stock experiments supposed to demonstrate the extreme vitality of life under dessication. Such eelworms, however, are in reality dead, and the wriggling is due to the absorption of water by their dessicated bodies, which causes them to expand and resume a life-like appearance. When the body of an eelworm is once properly saturated with water and expanded all movement ceases.

The disease is erratic in appearance, and as a rule does little harm, although Miss Ormerod mentions an instance where about twenty-seven acres of wheat was badly infected.

According to Bastian, when infected grains are sown along

with the seed they become soft, and the eelworms escape into the soil and make their way to the sprouting wheat, and insert themselves under the leaf-sheaths, where they remain until the ear commences to form, when they enter the soft, young grain, and a gall or 'ear-cockle' is produced.

Grain containing ear-cockles should not be used for seed. Some of the infected grains can be removed by screening the seed; or if the infected seed is placed in water, so that the liquid is a little above the grain, the light ear-cockles will come to the surface, and can be skimmed off. The grain should be stirred up, so as to allow all the diseased ones to come to the surface.

Bastian, C., *Trans. Linn. Soc.*, 25, p. 87.
Ormerod, E. A., *A Manual of Injurious Insects*, p. 104.

Beet-sickness, caused by *Heterodera sachtii* (Schum.), proves injurious to the sugar beet on the Continent; mangold, turnips, rape, cabbage, roots of some cereals and leguminous plants, and weeds of various kinds are also attacked. When a beet is attacked by eelworms the leaves become flabby, yellow, and soon die, the top of the root changes to a blackish colour, and the whole soon decays. The smaller rootlets bear numerous knots containing eelworms.

Kühn, a German scientist, has proposed the partial clearing of the land from eelworms, so that a fairly successful crop of beet may be secured, by means of a 'trap crop.' Summer rape has proved to be most successful, on account of its quick growth and large spread of root. Success depends on the prompt removal of the rape when the largest number of eelworms have entered the tissues of the root, and before a new brood is produced.

Lime, sulphate of potash, and salt have respectively been found to arrest the progress of eelworms in the soil.

Fern eelworm (*Aphelenchus olesistus*, Ritzema Bos) forms deep brown blotches on the fronds of various ferns—*Pteris cretica*, *Aneimia collina*, *Lygodium volubile*, *Adiantum capillus-veneris*, *Pteris Droogmantiana*, and other species. The shape of the brown blotches is determined by the venation of the frond. Where the veins are more or less parallel, as in *Lygodium*, the blotches take the form of narrow, parallel streaks, whereas when the veins anastomose irregularly the blotches are more or less angular. This arrangemen is due

to the fact that the eelworms in the tissues of a fern frond cannot extend beyond the portion of parenchyma circumscribed by a vein. According to Ritzema Bos, when the air is moist the eelworms migrate from old diseased parts of the leaf and enter the adjoining healthy portions, emerging and entering through the stomata, and that when attacked plants

FIG. 170.—*Aphelenchus olesistus.* 1, surface view of fragment of frond, showing eelworms under the surface of the epidermis. It will be observed that the size of the stomal opening is sufficiently large to admit the passage of the eelworm; highly mag.; 2, *Pteris droogmansiana*; 3, *Adiantum capillus-veneris*, form *fissa*; 4, *Lygodium volubile.* In the last three figs. the dark portions are caused by eelworms; reduced.

are placed in fairly dry air, the migration is checked. I have never seen eggs in the tissues of infested plants, and imagine that they are deposited in the soil in which the plant is growing, the eelworms ascending the plants and entering the tissues for feeding purposes only. I have found eelworms in abundance in the soil in which infected plants were growing. In addition to ferns, *Aphelenchus* lives in the leaves of many

flowering plants, *Chrysanthemum*, *Begonia*, *Calceolaria*, *Gloxinia*, *Coleus*, *Saint Paulia*, etc., forming more or less extended brown patches.

Much injury, attributed to *Thrips* and other agents, is often caused by this eelworm in greenhouses, etc.

Treating the soil with carbon disulphide destroys the eelworms, but not their eggs. Dusting the plants, when moist, with a mixture of tobacco powder and flowers of sulphur, prevents the eelworms from ascending and entering the leaves.

Strawberry 'Cauliflower' disease. — Strawberry plants often suffer from a serious disease caused by an eelworm (*Aphelenchus fragariae*, Ritzema Bos). The disease takes the form of a more or less consolidated or fasciated mass of stems, leaves, and flowers, all more or less grown together and forming a fleshy malformation, somewhat resembling a cauliflower in general appearance. Those flowers that remain free from the general mass assume monstrous forms. The eelworms are met with in abundance in the buds and are comparatively small. Miss Ormerod states that sulphate of potash at the rate of one cwt. per acre has had a good effect in stopping the disease and bringing a good crop; also at the rate of about one half cwt. per acre it has done well.

As a manurial application, a mixture of about two parts of sulphate of potash, three parts sulphate of ammonia, and four parts of phosphates brought remarkably healthy crops, with few exceptions.

Ormerod, E. A., *Handbook of Insects Injurious to Orchard and Bush Fruits*, p. 251 (1898).

Ritzema Bos, *Zeit. Pflanzenkr.*, 1, p. 1.

Aphelenchus ormerodis (Ritzema Bos) is a second species, also first observed attacking strawberry plants in England.

Ritzema Bos, *Zeit. Pflanzenkr.*, 1, p. 11.

ADDENDA

During the progress of this book through the press, various diseases new to this country have been observed. The same is true of other countries. Some of the more important are noted below.

Twig and bud disease of lilac.—Klebahn has quite recently described the various parasitic fungi and bacteria attacking the lilac (*Syringa vulgaris*). Amongst others, *Phytophthora syringae* (Klebahn) attacks and kills the tips of the shoots and also the buds. Large, elongated, wrinkled patches occur on the internodes of the stem. Conidia are produced on the surface, and numerous oospores are formed in the young tissues of leaf- and flower-buds.

Mycelium intercellular, branched, aseptate, thread-like haustoria enter the cells. Sporangia egg-shaped or ellipsoid, $40\text{-}75 \times 30\text{-}42\ \mu$, developed sympodially; swarm-spores egg-shaped, $9\text{-}11 \times 8\text{-}9\ \mu$, unsymmetrical, with two cilia attached laterally, the shorter one, $16\text{-}18\ \mu$ pointing forwards, the longer one, $23\text{-}30\ \mu$, pointing backwards. Oogonia and antheridia formed in the tissues of the host; oospores solitary in the oogonia, globose or rarely oval, $18\text{-}36 \times 17\text{-}25\ \mu$, wall thick, yellowish, smooth.

Klebahn, H., *Krankheiten des Flieders*, p. 18 (1909).

TREMELLA (Dill.)

Gelatinous, tremelloid, immarginate, generally smooth (not papillose as in *Exidia*), basidia globose, longitudinally cruciately quadripartite, each quadrant of the basidium elongating into a long, stout sterigma; spores subglobose, continuous. Conidia are produced in the sporophore in some species.

Tremella frondosa (Fries.) occurs on the trunks of trees, oak, etc., that are still living, and is suspected of parasitic tendencies, but there is no definite evidence on the point.

Gelatinous, tufted, large, 3-4 in. high and broad, sometimes

more; lobes undulate and contorted, smooth (not corrugated), base firmer, plicate, pale pinkish-yellow; spores subglobose, apiculate, 7-9 μ.

Other species, as *T. mesenterica*, etc., sometimes occur on living trees.

FIG. 171.—*Tremella frondosa*. Half nat. size. (After A. Clarke.)

Root rot of tobacco.—Dr. W. W. Gilbert has just issued an exhaustive account of *Thielavia basicola*, which he has proved

to be a true parasite, and the cause of root rot of tobacco. This disease has assumed very serious proportions in the United States, many instances being known where the entire crop of seedlings raised by a farmer had to be discarded because of the root rot caused by *Thielavia*. The diseased area at the present time is confined to Connecticut.

When plants are attacked in the seed-bed when quite young, the seedlings may 'damp off' when not more than one-third to half an inch high, the fungus attacking not only the root but also the stem up to the cotyledons. When the disease is not so virulent the root only is attacked, the injury usually commencing at the end of the taproot and gradually working upwards until the entire root-system is destroyed, and, as this takes place, the plantlet usually puts out numerous lateral roots. These serve the seedling for some time, but eventually become diseased and the plant perishes.

The ascospore stage is said to occur in abundance on old diseased roots of tobacco, and is borne in the midst of the conidial forms. Carefully conducted experiments proved *Thielavia* to be a true parasite.

The author's summary as to the conditions conducive to serious injury from root-rot are :—

(1) Infection of the seed-bed or the field with *Thielavia basicola*.
(2) A fairly heavy soil rich in humus.
(3) Excessive fertilisation.
(4) Heavy watering in the beds.
(5) Lack of ventilation in the beds.

The sterilisation of infected seed-beds by the methods herein described (preferably by steam) furnishes an effective means of preventing disease.

Gilbert, W. W., *U.S. Dept. Agric., Bureau of Pl. Industry*, Bull. No. 158 (1909).

Black rot of grapes.—This disease, caused by *Guignardia bidwellii* (Viala and Rav.), which proves such a scourge in vineyards in the United States, has occupied the attention of Dr. C. L. Shear for the past three years, with the result that spraying experiments prove that the most serious epidemics of black rot can be satisfactorily controlled by thorough and proper methods of spraying. It has also been found that

smaller quantities of copper sulphate and lime than previously used in the preparation of Bordeaux mixture give equally good results as the stronger mixture.

The following is Dr. Shear's summary:—

Bordeaux mixture, prepared according to the 4-3-50 formula (4 lbs. copper sulphate, 3 lbs. lime, 50 gallons water), has been found quite as effective in preventing black rot as the formulas in which larger quantities of copper sulphate and lime are used. Five or six applications, beginning when the shoots were eight inches to one foot long, gave generally as good results as when one or two additional earlier applications were made, showing apparently that no particular benefit is derived from dormant applications or from applications made when the shoots are less than eight inches long.

Where unsprayed grapes were a total loss from black rot in 1907, the rot on the sprayed plots was reduced to 28·3 per cent. The next season, 1908, when the rot was almost equally bad on unsprayed vineyards, the rot on the same sprayed plots was reduced to much less than one per cent., showing apparently the great cumulative effect of treatment for two seasons.

The gain, due to spraying, varied in different vineyards, according to the severity of the rot, the number of sprayings, the productiveness of the vines, and the cost of materials and labour, from 10·60 dollars to 62·30 dollars per acre.

The experiments have shown the necessity of covering the vines thoroughly with a fine spray of properly prepared Bordeaux mixture. When the black rot is serious or the foliage is very heavy, it is necessary to use trailers and have the nozzles directed by hand, as fixed nozzles will not properly cover the foliage and fruit.

The tests of various lime-sulphur preparations have not yet been sufficient to determine their value as a preventive of black rot.

Neutral copper acetate, one lb. to fifty gallons of water, has been found to be the best non-staining preparation tested in these experiments for final applications.

Shear, C. L., *U.S. Dept. Agric.*, *Bur. Pl. Industry*, Bull. 155 (1909).

Cucumber and mushroom bed fungus (*Xylaria vaporaria*, Currey) often forms dense masses of irregularly shaped, variously branched, black, corky sclerotia in the soil of cucumber,

melon, and mushroom beds. I have seen a barrow-load of these sclerotia taken from a comparatively small-sized cucumber frame. The sclerotia are buried in the soil, and if allowed to remain, produce simple or branched, upright, fertile stems above ground. These black stems are usually crooked and wavy, and the tip of each branchlet is terminated by an irregularly swollen knob bearing numerous perithecia in its substance, the mouths of which project slightly and give a papillate appearance to the surface of the knob. The asci in the perithecia each contain eight opaque, brown, almond-shaped continuous spores, 40-50 μ long.

When the fungus is present there is no cure; and as it spreads very rapidly, the only course is to remove the soil completely and replace by fresh soil mixed with a sprinkling of lime, or preferably with kainit.

Apple bark fungus (*Valsa ambiens*, Fries.) has been shown by Dr. M. C. Cooke to seriously affect the living bark of apple-trees, although the fungus is usually a pure saprophyte. The conidial form of the fungus first appears under the form of golden yellow tendrils oozing out of the living bark. These tendrils consist of myriads of minute conidia embedded in a gelatinous substance. This form was at one time considered as a distinct fungus called *Cytospora carphosperma* (Desm.). The ascigerous condition is produced after the bark is dead, and consists of clusters of flask-shaped perithecia arranged in clusters and embedded in the bark; each perithecium has a long, slender, cylindrical beak which projects beyond the bark, and through which the spores escape. Spores cylindrical, curved, ends rounded, hyaline, $16\text{-}18 \times 3\text{-}4\ \mu$.

Cooke, M. C., *Fungoid Pests of Cultivated Plants*, p. 120.

Tomato flower rot (*Fusarium solani*, Sacc.) a stage of *Nectria solani*, Reinke) is often responsible for the non-development and withering of the inflorescence of the tomato plant. As a rule the flowers do not expand, and along with the adjoining portions of the stem, become hairy and brownish. Eventually the conidia of the fungus, under the form of reddish, glairy masses, appear on the surface of the affected parts.

Parsley rot.—Parsley is sometimes seriously injured, more especially when grown in houses, by *Sclerotinia libertiana*

(Fckl.). The fungus forms a white mycelium on the surface of the soil, which attacks the plants at the collar and destroys the root. Numerous minute sclerotia are formed on the dead parts, and the soil becomes infected. Under the circumstances, fresh soil should be substituted, and the infected soil spread over grass land as the only place where it can do no further harm.

Celery heart rot.—Celery often suffers from a root rot which causes the heart of the plant to become soft and pulpy; finally the plant droops and dies. *Sclerotinia sclerotiorum* (Mass.) is the cause of injury; the conidial or *Botrytis* stage of the fungus appears first on the diseased parts as a grey mould, and is followed by the formation of numerous small black sclerotia on the dead portions of the plant. If these are allowed to remain on the land, future crops, with the exception of cereals, are endangered.

Details as to the method of treatment of this parasite have been given earlier in this book.

Onion bulb rot.—Quite recently a crop of white Portugal onions were destroyed by a wet rot, which caused the bulbs to deliquesce and give off a most offensive odour. On investigation it was found that *Sclerotinia sclerotiorum* (Mass.) was the cause of injury. On cutting open the bulbs, numerous black sclerotia were found located between the scales, which were also observed to be teeming with the mycelium of the fungus.

Monkey-nut leaf rust.—The leaves of *Arachis hypogea* are frequently attacked by *Uredo arachidis* (Lagerh.), which forms scattered or crowded, minute sori on the under surface of the leaf.

Uredospores subglobose or ovoid, brown, minutely echinulate, 25-35 μ diam.

As to whether there is any genetic connection between this uredo and *Uromyces arachidis* (P. Henn.), parasitic on the same host, is not known.

U. arachidis. Sori on both surfaces of leaf; teleutospores subglobose, elliptic or ovoid, clear brown, epispore thin, almost smooth, or minutely verrucose, $22\text{-}28 \times 20\text{-}26\ \mu$; pedicel fragile, hyaline, short.

Celery leaf spot.—This disease, caused by *Phyllosticta apii*

(Halst.), is mentioned on p. 413 as occurring in the United States on cultivated celery, has recently appeared in epidemic form on celery in this country. In some cases, large, scattered, and isolated spots are formed on the leaf, which remain dark brown, and become studded with the perithecia of the fungus. In other instances, the greater portion or the whole of the leaf becomes studded with small blackish patches, on which the perithecia are crowded.

Perithecia immersed, globose or ovoid, glabrous, blackish-olive, ostiolum minute, not at all prominent, conidia broadly elliptical, hyaline, $5\text{-}7 \times 3\text{-}4\ \mu$.

Indian corn mildew.—In the United States, maize, Indian corn, or corn, is frequently attacked by two closely allied species of fungi. The disease affects the ear, showing as a whitish mould, spreading over the surface of the grain, sometimes covering the whole ear, at other times localised in patches. The amount of mildew present on the surface of the grain is scanty, but upon breaking the ear the spaces between the bases of the grains are seen to be densely packed with a mass of snow-white mycelium. Numerous minute black specks of the fruit of the fungus may be found embedded in the mycelium situated at the point of attachment of the grain to the cob; such fruit is not produced on the superficial mycelium. These fruits may belong either to *Diplodia macrospora* (Earle) or to *Diplodia maydis* (Sacc.).

D. maydis, perithecia gregarious, black, beak conico-acute, conidia elliptic-cylindrical, sometimes clavulate, straight or curved, 1-septate, scarcely constricted, coloured, $25\text{-}30 \times 6\ \mu$.

Stevens and Hall, who have paid special attention to this disease, state that the damage is placed at from 10 to 50, to 75 per cent. of the value of the crop. Both species of *Diplodia* live on corn stalks, and the fungus multiplies on such old stalks. It is consequently most important to plough under all old stalks, leaves and shucks, so as to secure future crops from infection.

Stevens, F. L., and Hall, J. G., *Rep. N.C. Agric. Expt. Sta.*, 1907-08, p. 37.

Monkey-nut leaf blotch.—This plant, *Arachis hypogea*, known in the West Indies as 'earth nut,' and in the United States as 'pea nut,' is often severely injured by *Cercospora personata* (Ellis), which forms numerous more or less circular

dark brown or olive-green blotches on the leaves, varying from one to four mm. diameter.

Hyphae springing in dense, crowded tufts, brown, often more or less crooked, sparingly septate; conidia usually narrowly clavate, pale brown, 1-3 septate, $35\text{-}55 \times 6\text{-}7\ \mu$.

Lilac leaf blotch (*Heterosporium syringae*, Oudemans) forms large, irregularly shaped, greyish-brown, dry blotches on lilac leaves. The fruit of the fungus forms small blackish tufts which emerge through the stomata, or burst directly through the epidermis.

Pustules, black, regularly distributed on the patches, conidiophores septate, irregularly flexuous, slender, conidia very pale olive, 1-3 septate, wall minutely warted, the largest cylindrical, ends rounded, $25\text{-}30 \times 7\text{-}9\ \mu$.

Klebahn, H., *Krankheiten des Flieders*, p. 11 (1909).

'Internal disease' of potato tubers.—This disease up to the present has not been thoroughly understood. The general symptoms are the presence of more or less scattered, small rusty spots in the flesh, which is usually watery in an advanced stage of disease. Externally the tubers show no symptom of discoloration or disease. Sometimes examples of tubers said to show 'internal disease' have proved to be incipient cases of winter rot, caused by *Nectria solani*. In other instances, however, no trace of mycelium can be found in the diseased areas.

Quite recently Horne has paid attention to this disease, and in a preliminary note announces the presence of an endophyte, which has been found to be constantly present in all tubers affected with 'internal disease' that have been examined. The author states: 'Although the organism may exist within the cells of the host without doing any visible damage, it is capable under certain circumstances of causing deterioration and death of the host cells.'

The organism is said to begin growth as a small vesicle within a cell, being attached by a fine thread to the wall. These vesicles increase in size and form bladdery, sphaeroidal, or lobed bodies in cells with scanty contents. In cells containing starch the organism is flattened between the starch grains. The vegetative body gives rise to one or more spheres, capable of producing by budding at a number of points, a sorus of sori or sporangia within the membrane of

the sphere. The secondary spheres may behave as secondary sori, and budding may be continued until the ultimate spore form is reached. The spores give rise to exceedingly small swarm spores. The organism is best seen in a narrow pink, purple, or yellowish zone at the base of the eye, in the tissue surrounding the old stalk of the tuber, and in the wound cambium which surrounds the brown affected areas in the flesh. The most conspicuous objects are the pink or purplish thick-walled sphere-sori, located amongst the starch grains.

It is suggested that the organism be provisionally regarded as a Chytridiaceous fungus of generic rank.

The fuller account of this mysterious body will probably clear up the uncertainties that exist at present. It is to be regretted that the presence of the organism is not said to be present in the diseased portions of the tuber.

Horne, A. S., *Annal. Mycol.*, 7, p. 286 (1909).

'Sprain' of potato tubers.—Several examples of potatoes said to show the disease called 'sprain' in the north of England and Scotland, have at various times been sent to Kew. The appearance is so different in the various examples that it is impossible to draw up a satisfactory diagnosis. The most constant feature perhaps is the presence of rust-coloured patches scattered in the flesh. Very frequently the flesh also presents a water-logged appearance. These rusty spots closely resemble those present in the tubers of potatoes showing what is termed 'internal disease' in the south of England. In both instances the brown spots possess many features in common with those present in the disease of apples known as 'bitter-pit.' In some instances mycelium can be detected in the brown patches, and in such instances, when the slices of potato are placed under suitable conditions, 'winter-rot,' caused by *Nectria solani*, invariably makes its appearance. In other instances, however, no mycelium can be found, and such specimens, however long kept under suitable conditions, show no sign of winter rot. Perhaps in such instances the mycelium has by some means been checked early in its development. The whole subject requires to be thoroughly investigated before we are in a position to state definitely its cause.

Infectious chlorosis.—Dr. Clinton has noted the occurrence

of chlorosis, which can be transmitted from one plant to another in tomatoes, Lima beans, and musk melons. In some instances the disease could not only be transmitted by infection with the juice from a diseased to a healthy plant of the same kind, but also from a tomato to a tobacco plant, and back again to a tomato plant; the general appearance of the disease resembles in all instances the so-called 'calico disease' of tobacco, which is considered to be of a physiological nature.

Clinton, G. P., *Connecticut Agric. Expt. Sta. Rep.*, 1908.

Resin wash.—As the result of numerous experiments made with the object of checking the attacks of aphides and other insects that deposit 'honey dew' on foliage, and consequently encourage the growth of 'black mould' or 'sooty mould,' Webber recommends spraying with a solution prepared as follows:—

Resin, ...	20 pounds.
Caustic soda (98 p. c.), . .	$4\frac{1}{2}$ pounds.
Fish oil, crude, . . .	3 pints.
Water, to make, . . .	15 gallons.

Boil the resin, fish oil, and caustic soda, mixed with water, until the resin is dissolved, then make up to fifteen gallons with water. This is the stock solution. To use, add nine parts of water to one part of the stock solution.

A modification of this solution is recommended by Professor Webber.

Resin, ...	8 pounds.
Sal soda, ...	4 pounds.
Water, ...	1 quart.

After boiling together, add water to make up five gallons of stock solution.

Place the resin and sal soda in a large kettle with one quart of water. Boil, meanwhile stirring briskly, until the resin and sal soda are thoroughly melted together and form a frothy mixture without lumps. Now add about four gallons of cold water, pouring it in rather slowly and with short intervals between to avoid chilling the mixture too suddenly. When all the water has been added, bring it to a boil, then pour out the hot solution, straining it through a coarse cloth, and add sufficient water to make exactly five gallons of the solution. This, if properly made, forms a thick, dark brown, translucent, syrupy solution, which may be preserved as a

stock solution. For use in treating the 'sooty mould' following the white fly (*Alcyrodes citri*), dilute this stock solution in the proportion of one part to seven parts of water.

Webber, *Proc. Ninth Ann. Meeting Florida State Hort. Soc.* (1896).

Influence of Bordeaux mixture on the yield of potatoes.—It has frequently been stated that apart from its fungicidal action, Bordeaux mixture acts beneficially on potatoes, and the result is a better crop. Kirchner has conducted a series of experiments extending over three years, for the purpose of determining the value of such statements. The first season showed practically no difference between sprayed and unsprayed plots. During the second season the balance was in favour of the sprayed plots, whereas during the third season, when the plants were sprayed four times with a 2 per cent. solution of Bordeaux mixture, the crop yield and starch percentage were both decidedly in favour of the unsprayed plot. Taking the percentage of the unsprayed plot at 100, then the crop percentage of the sprayed plot would be represented by 69·4, and the starch percentage as 68·4.

During the third year of the experiments the weather was very damp and cloudy, and it is considered that possibly the presence of Bordeaux mixture on the leaves might to some extent interfere with the performance of their functions.

Kirchner, O., *Pflanzenkrankh.*, 18, p. 65.

Bitter-pit of the apple.—This disease has quite recently been investigated by Pole Evans. His summary is as follows:—

'Bitter-pit is an abnormal spotting of the fruit of the apple. It results from the bursting and consequent breaking down of certain cells of the flesh due to too great internal pressure. This great pressure is set up by the external conditions to which the trees are exposed. These trees are not of themselves plastic enough to adapt themselves to their environment, and thereby regulate their physiological functions, with the result that abnormal forces are brought into play with which the plant is unable to cope in the ordinary course of events. In consequence thereof abnormal physiology leads to disease conditions. The main factors that are responsible for the spotting are believed to be excessive transpiration during the day, followed by its sudden checking and com-

plete abeyance during the night, when root action is still vigorous owing to the warmness of the soil. Under these circumstances water accumulation takes place to such an extent in the cells of the fruit that an actual bursting of the cells may occur.'

It is stated that no ready remedy can be offered, and it is believed that the only method of overcoming the difficulty is by making a clean start by raising South African seedlings in the localities where the fruit is to be grown. By such means it is considered that adaptation to environment could be best brought about.

I am afraid this is somewhat cold comfort, considering the fact that bitter-pit is often rampant in Europe on the offspring of trees that have had ample time to become acclimatised.

Pole Evans, J. B., *Transvaal Dept. Agric.*, Bull. No. 1 (1909).

Annual loss on farm crops due to fungi.—Professor W. A. Orton, in an article on the importance of the development of farm crops resistant to disease, justifies his statements by pointing out that the present losses from plant diseases are a heavy tax upon the farmer. He states that in the United States alone the average annual loss from oat smut is more than $6,500,000; from loose-smut of wheat, $3,000,000; and from bunt, or stinking smut of wheat, more than $11,000,000. Loose-smut annually diminishes the value of barley $2,000,000, a careful estimate of the loss in one State last year placing it as 7 per cent. The combined effect of the various diseases of fungal origin attacking the potato, diminish the yield of this crop over $36,000,000 each year. The above account shows that an annual loss amounting to over £11,000,000 is sustained, due to the injury caused by fungi to cereals and potatoes alone.

This, however, is not all; it is further stated that the losses from the cereal rusts and from the numerous minor troubles of farm crops, concerning which accurate data are difficult to secure, amount to hundreds of millions of dollars.

Vast as is the direct loss arising from plant diseases, the indirect losses are also great, as the expense of treating plant diseases is also very considerable. Of still greater importance is the indirect loss resulting from the limitation of industries. The risk from disease frequently operates to reduce the

production of otherwise profitable crops, and in many instances industries have been abandoned on this account.

The author evidently looks upon the present methods of combating fungus diseases as both costly and unsatisfactory, and indicates the need of immune varieties.

'One of the most effective methods of dealing with plant diseases is to improve our crops so that they will be less subject to injury. When we can introduce into our agriculture varieties possessing a degree of natural immunity and thereby avoid both the loss from disease and the necessity for the more or less expensive treatment by sprays and other means, a double economic gain will be secured.'—('Year-Book,' United States Department of Agriculture.)

Black scab of potato.—Professor Percival has just published an account of the organism causing black scab in potatoes, and comes to the same conclusion that I expressed at a meeting of the Linnean Society some months ago, and in this book on p. 98, viz., that the organism belongs to the genus *Synchytrium*. Percival suggests the name *Synchytrium endobioticum*, which having priority of publication, will be accepted in the future. The specific name *endobioticum* implies that Percival considers his fungus to be identical with *Chrysophlyctis endobiotica* (Schilb.). At the page quoted above I have stated reasons for considering it to be quite distinct from Schilbersky's fungus, hence suggested the name *Synchytrium solani.*

Percival J., *Centralbl. für Bakt. Parasit. u. Infectionskr.*, p. 440, 1909.

Conifer bud disease.—Dr. Borthwick has described a disease of *Picea pungens*, caused by *Cucurbitaria piceae* (Borthwick). The fungus forms a thick, black, crust-like stroma completely enveloping the bud. On this stroma numerous black perithecia are eventually produced.

Mycelium intercellular, perithecia closely crowded, stipitate, springing from the stroma, black, carbonaceous; asci clavate, 4-6-spored, spores uniseriate, cymbiform, 4-10-septate, muriform, $20 \times 6\,\mu$; paraphyses filiform.

Borthwick, A. W., *Notes from Roy. Bot. Gard. Edinb.*, No. 20, p. 259 (1909).

Cucurbitaria pithyophila (De Not.) forms black, crust-like stromatic patches on the bark of various species of *Abies* and *Pinus*. These stromata eventually produce numerous black perithecia.

Perithecia globose then collapsing; asci subcylindrical, 8 spored; spores elliptic-oblong or obtusely fusiform, constricted as a rule at the centre, 3-4-septate, sparingly muriform, smoky, $18\text{-}25 \times 7\text{-}8\ \mu$; paraphyses slender, sometimes branched.

A pine disease (*Diplodia pinea*, Kickx) attacks the leaves and young shoots of various species of *Pinus* in Europe. The leaves fall prematurely and the shoots are eventually killed, but remain for some years before they fall, and produce annually a crop of spores which infect adjoining branches or trees. The disease is most injurious to nursery stock, as apart from the injury to the young trees, there is the danger of introducing the disease into the forest. The fruit appears under the form of minute black spots, which are usually very numerous on the dead branches, occurring more sparingly on the leaves. Experiments conducted at Kew showed that species belonging to the genus *Pinus* could be readily infected by the spores, *P. strobus* and *P. silvestris*, whereas species of *Picea*, *Abies*, and *Larix* resented all attempts at infection. Quite recently specimens of *Pinus insignis* and *Pinus pinaster*, badly attacked by this disease, have been received at Kew from the eastern forests of Cape Colony. The mycelium is most abundant in the cortex and phloem, sometimes extending for some distance along the medullary rays.

Perithecia minute, black, bursting through the epidermis or cortex. Conidia elliptic-oblong, dark coloured, becoming 1-septate, $40\text{-}45 \times 17\text{-}20\ \mu$.

When nursery stock is diseased it should be removed and burned, otherwise the infection spreads rapidly, and if the fungus is introduced to the forest large trees are attacked, for which there is no remedy.

Massee, *Bd. Agric. Leaflet*, No. 199.

The making and application of Bordeaux mixture.—Mr. E. S. Salmon has just published an important and detailed account of the making and application of Bordeaux mixture, the outcome of extensive practical work and observation.

One point strongly insisted upon is that home-made Bordeaux mixture is much superior to any preparation at present on the market. The formula recommended is as follows:

Copper sulphate ('bluestone'), . .	4 pounds.
Quicklime (in lumps), ...	4 pounds.
Water, ...	50 gallons.

In purchasing copper sulphate, 98 per cent. purity should be insisted upon. The lime should be quicklime, in lumps, as freshly burnt as possible. Powdered, air-slaked lime will not make Bordeaux mixture. Spraying machines, nozzles, etc., are discussed, and the forms best adapted for special requirements are indicated. It is imperative that the spray should be very fine and misty, otherwise unsatisfactory results follow.

Salmon, E. S., *Journ. Bd. Agric.*, January 1910.

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[*Over*

Specimen Illustration from "Agricultural Botany."

A B C D

FIG. 169.—Chief beardless types of Common Wheat (*Triticum vulgare* Vill.).
A, Loose-eared type, Talavera.
B, Do. Hunter's White.
C, Dense-eared type, White Victoria.
D, Square-head type, Sheriff's Squarehead.